180401

Air Quality in Ontario
1990

Ontario
Environment
Environnement

27/03/92

© Queen's Printer for Ontario, 1992
ISSN 0840-9366
PIBS 1804$_{01}$

PRINTED ON
RECYCLED PAPER
IMPRIMÉ SUR
DU PAPIER RECYCLÉ

AIR QUALITY IN ONTARIO 1990

A review of the Ministry of the Environment
air quality monitoring program for 1990

EXECUTIVE SUMMARY 1

INTRODUCTION 5

GLOSSARY 6

ABBREVIATIONS 6

SECTION A - MONITORING NETWORK OPERATIONS

1.0 Network Description 7
1.1 Quality Assurance and Quality Control 7
1.2 Data Base 7

SECTION B - POLLUTANTS MEASURED BY CONTINUOUS MONITORS (HOURLY DATA)

2.0 Sulphur Dioxide (SO_2) 9
3.0 Suspended Particles (SP) 9
4.0 Total Reduced Sulphur Compounds (TRS) 10
5.0 Carbon Monoxide (CO) 11
6.0 Hydrocarbons (THC/RHC) 11
7.0 Nitrogen Dioxide (NO_2) 12
8.0 Nitric Oxide (NO) 13
9.0 Oxides of Nitrogen (NO_x) 13
10.0 Ozone (O_3) 13

SECTION C - THE ONTARIO AIR QUALITY INDICES

11.0 Air Quality Index (AQI) 16
12.0 Air Pollution Index (API) 20
13.0 Lambton Industrial Meteorological Alert (LIMA) 25

SECTION D - POLLUTANTS MEASURED BY HIGH VOLUME SAMPLER (DAILY DATA)

14.0 Total Suspended Particulates (TSP) 26
15.0 Inhalable Particulate (IP) 26
16.0 Lead in TSP (Pb) 27
17.0 Trace Metals in TSP (Cadmium, Chromium, Iron, Manganese, Nickel, Vanadium, Copper) 28
18.0 Nitrate in TSP (NO_3^-) 29
19.0 Sulphate in TSP (SO_4^{2-}) 29

SECTION E - POLLUTANTS MEASURED BY DUSTFALL JAR AND FLUORIDE CANDLE (MONTHLY DATA)

20.0 Total Dustfall (TDF) 32
21.0 Fluoridation Rate (FLR) 32

SECTION F - PROVINCIAL TRENDS IN AIR QUALITY AND EMISSIONS

22.0 10-Year Trends in Air Quality and Province-wide Emissions 34
23.0 Ambient Air Quality Comparison in Selected North American Cities 41

SECTION G - METEOROLOGY AND AIR QUALITY

24.0 Summary of Meteorological Conditions (1990) 45
25.0 Discussion of Ozone and SP Episodes 45

TABLES

1 Highlights of the Continuous Monitoring Network (1990) 15
2 Air Quality Index Pollutants and Their Impact 17
3 Air Quality Index Summary (1990) 18
4 Number of Hours/Days of Unacceptable Air Quality at AQI Sites 20
5 Ten-Year History of the Air Pollution Index (1981 - 1990) 21
6 Lambton Industrial Meteorological Alert Summary (1981-1990) 25
7 Comparison of Inhalable Particulate (IP) Versus Total Suspended Particulate July 1989 to January 1991 27
8 Highlights of the Particulate Monitoring Network (1990) 31
9 Ranking of Metropolitan Areas According to Criterion Pollutant Levels 41

FIGURES

1a Ontario Ambient Air Quality Monitoring Program from 1971-1990 8
1b Continuous Monitors in Cities/Towns in Ontario with a Population of 100,000+ 8
2 Number of Hours of Unacceptable Air Quality at AQI Sites in Ontario 1990 19
3 Long Term Trends in SO_2, CO, TSP and Pb in Ontario 34
4 10-Year Trend for SO_2 Across Ontario 35
5 Ontario Sulphur Dioxide Emission Trend (1970-1990) 35
6 10-Year Trend for CO Across Ontario 36
7 Ontario Carbon Monoxide Emission Trend (1981-1990) 36
8 Ontario Vehicle-Kilometers Travelled (1981-1990) 36
9 10-Year Trend for NO_2 Across Ontario 36
10 10-Year Trend for NO Across Ontario 36
11 Ontario Nitrogen Oxides Emission Trend (1981-1990) 36
12 10-Year Trend for O_3 Across Ontario 37
13 Ontario VOC Emission Trend (1981-1990) 37
14 Reduction in Ontario VOC Emission Due to Lower Gasoline RVP in Summer 37
15 10-Year Trend for SP Across Ontario 38
16 10-Year Trend for TRS Across Ontario 38
17 10-Year Trend for TSP Across Ontario 39
18 Ontario Particulate Emission Trend (1981-1990) 39
19 10-Year Trend for Pb in TSP Across Ontario 40
20 10-Year Trend for Mn in TSP Across Ontario 40
21 10-Year Trend for Cu in TSP Across Ontario 40
22 10-Year Trend for Fe in TSP Across Ontario 40
23 10-Year Trend for NO_3^- in TSP Across Ontario 40
24 10-Year Trend for SO_4^{2-} in TSP Across Ontario 40
25 (a) Comparison of SO_2 Levels at Selected North American Cities 42
  (b) Comparison of TSP Levels at Selected North American Cities 42
  (c) Comparison of NO_2 Levels at Selected North American Cities 43
  (d) Comparison of CO Levels at Selected North American Cities 43
  (e) Comparison of O_3 Levels at Selected North American Cities 44
26 Annual Wind Roses for Selected Meteorological Sites Across Ontario 47

EXECUTIVE SUMMARY

This is the twentieth annual report documenting air quality in Ontario. New additions to the Air Quality in Ontario - 1990 report include a brief discussion of the Lambton Industrial Meteorological Alert (LIMA), province-wide emissions data, inhalable particulate data (PM-10 fraction), total dustfall and fluoridation rate data, and a brief ambient air quality comparison between selected North American cities.

The Ontario routine air monitoring network reached its maximum size of 450 instruments in 1980. Since then, the number of instruments has been reduced by 7 percent such that in 1990 there were a total of 418 instruments: 279 continuous monitors and 139 hi-volume particulate samplers.

Undesirable air quality was measured on a number of occasions during 1990. As in the previous years, ozone (O_3) and suspended particles[1] (SP) were the contaminants which exceeded the provincial air quality criteria (AQC) most frequently. Out of 49 O_3 stations, 45 (92 percent) recorded at least one exceedance of the 1-hour AQC while for suspended particles, 25 stations out of 43 (60 percent) recorded exceedances of the 24-hour SP criterion. Exceedances for sulphur dioxide (SO_2) were recorded at 17 out of 72 monitoring locations while exceedances for total reduced sulphur compounds (TRS) were measured at 23 of 33 locations. The 10-year trends indicate a slight improvement for SO_2 over the decade and improvement in the early 1980's for carbon monoxide (CO) and TRS. Suspended particles, nitrogen dioxide (NO_2) and hydrocarbons (HC) have shown little change over the 10-year period. For the corresponding emission levels in Ontario, the 10-year trends show a reduction in sulphur dioxide emissions and minor changes in CO, NO_x and volatile organic compound (VOC) emissions between 1981 and 1990.

Undesirable air quality levels were reached on a number of occasions for 24-hour averaged total suspended particulate (TSP) concentrations. Out of 139 hi-volume stations, 86 (62 percent) recorded at least one TSP exceedance during the year. The annual TSP criterion was exceeded at 13 percent of the monitoring stations.

Five sites recorded exceedances of the 24-hour lead criterion while one exceedance of the 24-hour manganese criterion was measured during 1990. The 10-year trends show a slight improvement in total suspended particulate levels and significant improvement in lead and copper levels throughout the province. Iron and manganese levels show an increase throughout the 10-year period while sulphate and nitrate show year to year variability. Total particulate emissions, excluding those due to fugitive sources and forest fires, showed no significant change during the 10-year period.

Results from the Air Quality Index (AQI) system show that during 1990, moderate to poor air quality was recorded for at least one hour at all AQI sites. The frequency of days on which at least one hour of moderate air quality was recorded ranged from 1 to 56 percent depending on the site. Elevated levels of ozone and suspended particles were the most frequent cause of high index readings at the majority of AQI sites across Ontario. SO_2 was largely responsible for elevated AQI readings in Sudbury and TRS was the pollutant primarily responsible for elevated AQI readings in Cornwall and Fort Frances.

The Air Pollution Index (API), derived from a combination of SO_2 and SP, is still the basis of the alert system for air pollution control in Ontario. The advisory level of 32 was reached 10 times at seven sites across Ontario. The maximum value of 42 was recorded at the Hamilton Downtown site on March 16 and at the Sudbury Science Centre on October 24. The API incident in Hamilton was dominated by suspended particles while the incident at Sudbury was due primarily to SO_2.

The Lambton Industrial Meteorological Alert (LIMA), which is the basis of a SO_2 alert system for a section of Lambton county (including Sarnia) in southwestern Ontario, was called on nine occasions in 1990. The longest duration of the alert was 21 hours, lasting from January 3 at 1600 EST to January 4 at 1300 EST.

Ambient air quality in Metro Toronto was worse than that in Montreal, Vancouver, Boston, Atlanta and Chicago for the most recent comparable year, 1989. This was based on a

---

1. Particles with a diameter less than 44 microns are considered to behave as a gas since they are small enough to stay suspended for long periods of time. In our usage, the instrumentation which measures suspended particles (SP) restricts the size to particles less than about 10 microns. This is also the size range of most concern from a human health perspective.

system where each city was ranked according to five individual criterion contaminants (SO_2, TSP, NO_2, CO and O_3) using all of the data measured in the monitoring networks in each metropolitan area. The individual rankings were summed to determine an overall score. The details are given in Section 23.0.

Meteorological conditions such as wind speed and direction, atmospheric stability, slow moving or stalled high pressure systems, and air temperatures play a major role in the occurrence of high air concentrations of various contaminants. Variations in air concentrations from day to day are mostly due to meteorological factors. In 1990, there were 9 ozone episodes of 1 day's duration and 2 episodes of 2 days' duration. The 13 ozone episode days during 1990 were significantly less than the 36 and 18 episode days for 1988 and 1989 respectively.

INTRODUCTION

In the early 1950's, routine air monitoring of sulphur dioxide was conducted in the Sudbury region to assess the impact of the Inco and Falconbridge Smelting operations on the environment. With the passage of the Air Pollution Control Act in 1967, the task of air pollution control was centralized in an agency of the provincial government and by 1971, 76 sampling sites were operating across Ontario. In 1990 measurements of gaseous contaminants were made at over 99 locations and particulates were measured at 139 sites.

It should be noted that the province maintains three other monitoring networks throughout Ontario: the urban toxics network which monitors the levels of toxic volatile and semivolatile organic compounds in urban areas; the toxic deposition network which monitors the atmospheric deposition of pesticides and other semivolatile organic compounds, as well as trace metals into the Great Lakes basin; and finally, the acid deposition network which monitors the effects of emissions abatement on acid deposition across the province. Information pertaining to these three networks is available elsewhere[2].

This report describes the 1990 Ontario routine air quality monitoring program including a summary of the measurements of gases and particulate matter as well as a summary of meteorological conditions during the year. It is intended to be used in conjunction with the Appendix which appears in a separate volume.

The characteristics, effects, Ontario criteria (if any), sources, method of monitoring, and locations (and frequency) of sampling are discussed for each of the gaseous and particulate contaminants.

New additions to this year's report include a brief discussion of the Lambton Industrial Meteorological Alert (LIMA), province-wide emissions data, inhalable particulate data (PM-10 fraction), total dustfall and fluoridation rate data and a brief ambient air quality comparison of selected North American cities for 1989.

The ambient air quality data collected from the Ontario Ministry of the Environment monitoring network has been subjected to stringent quality control and quality assurance programs. The purpose of these programs is to ensure that the air quality data collected by the Ministry have attained acceptable levels of accuracy, precision and completeness. Section A of this report gives a brief discussion of the quality assurance and quality control procedures as well as a description of the data base.

The entire continuous (hourly) network is summarized in Appendix Table A-1 and Maps 1 and 2. This table gives station name, numerical identifier, and an indication of the "continuous" pollutants measured. Letter codes indicate whether data were telemetered or chart-read.

The "continuous" contaminants include SP (suspended particles) measured in coefficient of haze (COH) units as well as the following gases:

SO_2	(sulphur dioxide)
CO	(carbon monoxide)
O_3	(ozone)
NO_2	(nitrogen dioxide)
NO	(nitric oxide)
NO_x	(oxides of nitrogen)
THC	(total hydrocarbons)
RHC	(reactive hydrocarbons)
TRS	(total reduced sulphur)

Section B of this report describes each of the "continuous" contaminants in sequence. Section C deals with the Air Quality Index system, the ten-year history of the Air Pollution Index and a brief summary of the Lambton Industrial Meteorological Alert system.

The (daily) particulate (Hi-Vol) network is summarized in Appendix Table A-3 and Maps 4 and 5. This table provides station name, numerical identifier, and the various "daily" pollutants measured. Also, numerals indicate the monitoring cycle frequency in days. Some additional codes are defined in the key at the top of the table. The main particulate contaminants measured are:

---

[2] Contact for Information is Supervisor, Special Studies/Research Management Unit, Air Resources Branch, 4th Floor, 880 Bay Street, Toronto, Ontario, M5S 1Z8, Tel. (416) 326-1691.

TSP	(total suspended particulate)
IP	(inhalable particulate)
Cd in TSP	(cadmium)
Cr in TSP	(chromium)
Fe in TSP	(iron)
Mn in TSP	(manganese)
Ni in TSP	(nickel)
Pb in TSP	(lead)
V in TSP	(vanadium)
Cu in TSP	(copper)
NO_3^- in TSP	(nitrate)
SO_4^{2-} in TSP	(sulphate)

Section D describes each of the "daily" or particulate contaminants under the headings of TSP, IP, Lead, Trace Metals, Nitrate and Sulphate. These data are typically collected at a frequency of once every 1, 3 or 6 days.

The (monthly) dustfall and fluoridation networks are summarized in Appendix Table A-5. This table provides station name, numerical identifier and the various "monthly" parameters measured. The main "monthly" contaminants measured are:

TDF	(total dustfall)
FLR	(fluoridation rate)

Section E describes each of the "monthly" contaminants under the headings TDF and FLR. These data are collected at a frequency of once every month.

Section F of this report shows the provincial trends in air quality and emissions and also provides a brief comparison of air quality levels in six North American cities.

The meteorological network is described in Appendix Table A-6 and Maps 6 and 7. The table provides station name, numerical identifier, the various meteorological parameters measured as well as the height above ground at which the measurements were taken.

Section G summarizes the general meteorological conditions for 1990 (See also Figures A-1 to A-8) and presents a brief discussion of episodes with moderate or poor air quality due to ozone or suspended particles.

Queries relating to this report or requests for data (magnetic tape or hard copy) should be addressed to:

Quality Assurance, Telemetry and Analysis Unit
Air Resources Branch
125 Resources Road
Rexdale, Ontario
M9W 5L1
Telephone (416) 235-5780 or (416) 235-5778.

GLOSSARY

COH - the co-efficient of haze measurement yields an estimate of the amount of fine suspended particulate matter by measuring the amount of light scattering.

Criterion - a desirable maximum ambient air concentration or level (based on potential effects).

Detection limit - the minimum air concentration of a contaminant that can be determined by a specified analytical method.

Geometric mean - a statistic of a data set calculated by taking the nth root of the product of all (n) values in a data set.
- provides a better indication than arithmetic mean of the central tendency for a small data set with extreme values.

Percentile value - the percentage of the data set that lies below the stated value.
- for example, if the 70 percentile value is 0.10 ppm, then 70% of the data are below 0.10 ppm.

Primary pollutant - a contaminant which is directly emitted to the atmosphere.

Secondary pollutant - a contaminant which is formed from other pollutants present in the atmosphere.

Correlation coefficient - a measure of the strength of the relationship between two variables.

"Continuous" pollutant - a contaminant for which a continuous record exists; effectively, pollutants which have hourly data (maximum 8760 values per year).

"Daily" pollutant - a contaminant for which there exists only a 24-hour or daily value (maximum 365 values per year).

"Monthly" pollutant - a contaminant for which there exists only a monthly (30-day) value (maximum 12 values per year).

ABBREVIATIONS

AQC - air quality criterion.
COH - coefficient of haze reported as SP
ppb - parts (of contaminant) per billion (parts of air).
ppm - parts (of contaminant) per million (parts of air).
$\mu g/m^3$ - micrograms (of contaminant) per cubic metre (of air).
$gm/m^2/30$ days - grams (of contaminant) deposited per square metre per 30-day period.
$\mu g/100\ cm^2$/month - micrograms (of contaminant) per 100 square centimetres per month.

SECTION A - MONITORING NETWORK OPERATIONS

1.0 Network Description

In 1971 the provincial monitoring network consisted of 254 instruments: 166 continuous analyzers at 76 monitoring sites and 88 sites with high volume samplers (Hi-Vols). By 1980, the provincial network had reached its maximum size at 450 instruments of which 268 were continuous analyzers at 106 sites and 182 Hi-Vol monitors. Since 1980, the total number of instruments operating across Ontario has decreased by about 7%. In 1990, the network consisted of 418 instruments: 279 continuous monitors for nine gases at up to 99 sites, and Hi-Vols at 139 sites. Figure 1a shows the distribution of the number of instruments operating in Ontario since 1971 while Figure 1b displays the number of continuous monitors in cities/towns in Ontario which have a population in excess of 100,000.

1.1 Quality Assurance and Quality Control

The Air Resources Branch maintains a reference standards laboratory with gas standards that are referenced to the U.S. National Institute of Standards and Technology (NIST) as well as to the Pollution Measurement Division of Environment Canada. Performance audits are performed on the SO_2, NO/NO_2, O_3 and TRS (as H_2S) monitors three times per year and on CO and hydrocarbon (as methane) monitors annually. Hi-volume and PM-10 samplers are audited annually to determine the accuracy of the flow rate measurements. Deviation of ± 10 percent from the audit standard is the criterion for performance acceptability.

The ambient air quality monitoring network is subjected to continuous maintenance and quality control programs. The real-time continuous and particulate air quality data are constantly reviewed, assessed and validated by Regional staff and staff of the Air Resources Branch. Remedial actions are taken immediately to rectify any problems that may affect the validity of the data.

In 1990, the Provincial continuous air monitoring instruments were subjected to 799 performance audits. Eighty percent of the audits were found to be within the acceptable performance criterion of ± 10%. For the remaining 20% which fell outside the 10% criterion, station log records and backup charts were consulted to correct data. As a result, the MOE monitoring network for 1990 had 95.9% valid data.

The Hi-Vols were subjected to 186 performance audits in 1990. Eighty-six percent of the audited instruments were within the ± 10% acceptable criterion.

1.2 Data Base

The ambient air quality data used in this report are stored in MOE's Air Quality Information System (AQUIS). Approximately 4 million air pollution measurements are added to AQUIS on an annual basis with the vast majority representing the more heavily populated urban areas within Ontario.

Two statistical tests, the pattern test and the gap test, are used as a final data screening procedure to identify data anomalies. The pattern test checks for unusual pollutant behaviour. A set of limits for each pollutant has been defined from historical data. Values that are outside these limits are flagged for further investigation. The gap test identifies possible data anomalies by examining the length of the distance between the two largest values, the second and the third largest values, and similarly for other gaps.

The AQUIS data are divided into three major groupings: daily (24-hour) measurements, continuous (1-hour) measurements and monthly (30-day) measurements. The daily measurements are obtained from instruments that provide one measurement per 24-hour period and are typically operated on a 1,3 or 6 day sampling schedule. Such instruments are used to measure total suspended particulates, inhalable particulate, lead, various trace metals, sulphate and nitrate.

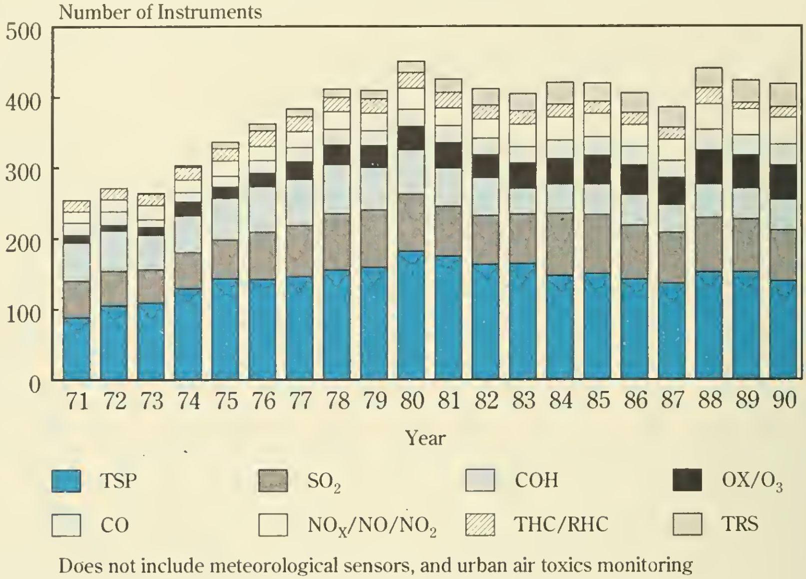
For daily data, a valid annual mean requires at least two thirds of the total number of possible samples, i.e., a station operating on a 6-day sampling schedule would require at least 40 out of a possible 61 samples.

The hourly data are obtained from ambient air monitoring instruments that operate continuously, producing a measurement every hour for a possible total of 8760 hourly measurements in a year. A valid annual mean requires at least 5840 hourly readings or 67% valid data.

The monthly data are obtained from the collection of settleable particulate over a 30-day period producing 12 monthly measurements per year. A valid annual mean requires at least seven out of a possible 12 values.

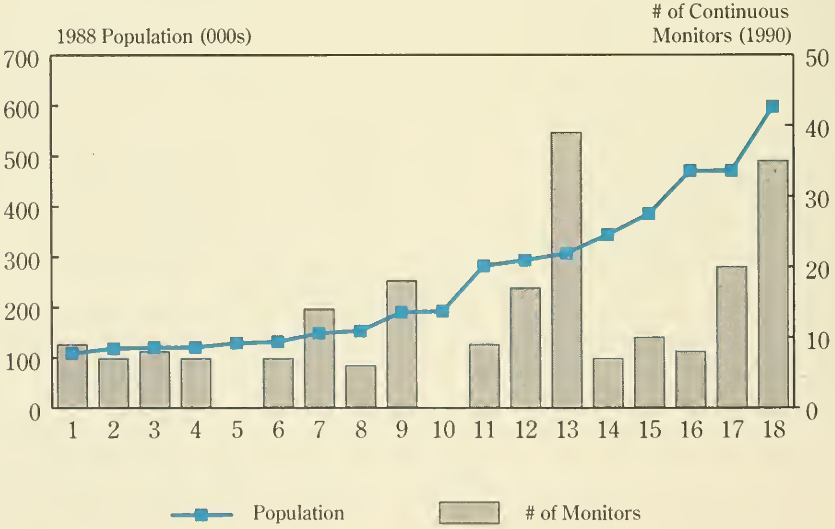
In order for a monitoring site to have been included in the 10-year trend analysis the site had to have a valid annual mean for at least 8 out of the 10 years 1981-1990, and to be included in the "long term" 20-year trend analysis the site had to have a valid mean for at least 18 out of the 20 years 1971-1990.

Figure 1a
Ontario Ambient Air Quality Monitoring Program from 1971 to 1990



Does not include meteorological sensors, and urban air toxics monitoring

Figure 1b
Continuous Monitoring in Cities/Towns in Ontario with a Population of 100,000+



1. Thunder Bay
2. Burlington
3. St. Catharines
4. Oshawa
5. Markham
6. York
7. Sudbury
8. Kitchener
9. Windsor
10. Brampton
11. London
12. Etobicoke
13. Hamilton
14. Ottawa
15. Mississauga
16. Scarborough
17. North York
18. Toronto

SECTION B - POLLUTANTS MEASURED BY CONTINUOUS MONITORS (HOURLY DATA)

SO_2

SULPHUR DIOXIDE

2.1 Characteristics

SO_2 is a colourless gas with a strong, pungent odour over 0.5 ppm.

2.2 Effects

1 hour average	
less than .16 ppm	• no known effects
0.16 ppm	• injurious to sensitive species of vegetation in combination with ozone.
0.26 ppm	• injurious to sensitive vegetation.
0.34 ppm	• odourous, increasing vegetation damage.
2.00 ppm	• increasing sensitivity to individuals with asthma and bronchitis.

2.3 Ontario Criteria

0.25 ppm (1-hour)
0.10 ppm (24-hours)
0.02 ppm (1-year)

2.4 Sources

80 percent of the SO_2 emitted in Ontario originates from non-ferrous smelters and electric utilities. A major fraction of the remaining 20 percent comes from other industrial sources including iron ore smelters, petroleum refineries, pulp and paper mills and area sources including residential, commercial and industrial space heating.

2.5 Method of Monitoring

Fluorescent excitation of SO_2 by pulsed ultra-violet radiation.

2.6 Locations of Monitors

The Appendix provides a description of the provincial SO_2 network (Table A-1).

SO_2 monitoring was conducted at 75 locations in 1990.

2.7 Monitoring Results

The distribution by percentile of the hourly data, the annual average, and the maximum one-hour and 24-hour values are provided in the Appendix (Table A-7). Also given are the number of exceedances of the sulphur dioxide criteria (see Section 2.3).

The lowest annual average SO_2 level in the province was measured in Thunder Bay (63200), where the hourly SO_2 readings never exceeded 0.03 ppm.

The greatest number of exceedances of the 1-hour and 24-hour criteria and the highest annual mean (0.02 ppm) were measured at Copper Cliff (77218) in Northeastern Ontario near the Inco Smelter operations.

There were a total of 17 SO_2 stations throughout the province where the hourly SO_2 criterion was exceeded at least once and seven where the 24-hour criterion was exceeded. There were no exceedances of the annual criterion during 1990. (See Table 1).

SP

SUSPENDED PARTICLES

3.1 Characteristics

SP is defined as a relative measure of suspended particulate matter of size most likely to reach the lungs (diameter less than 5-10 microns). It is determined by the amount of soiling caused by air flow on a filter medium.

3.2 Effects

1 hour average	
less than 2.0 COH units	• no known effects
2.0 COH units	• decrease in visibility
4.0 COH units	• soiling evident
6.0 COH units	• increasing sensitivity to individuals with asthma and bronchitis

3.3 Ontario Criteria

1.0 COH unit (24-hours)
0.5 COH unit (1-year)

3.4 Sources

Industrial processes which include combustion, incineration, construction, mining, metal smelting, processing and grinding. Also motor vehicle exhaust and road dust. Natural sources include wind-blown soil, forest fires, ocean spray, volcanic activity.

3.5 Method of Monitoring

Continuous paper tape sampler with sampling inlet and flow rate regulated to favour small airborne particles.

SP is determined by drawing a measured volume of air through a portion of paper tape which moves through an automated sampling unit to produce a reading every hour. The reduction of light transmitted through the tape is expressed as coefficient of haze (COH) per 1,000 linear feet of air sampled.

3.6 Locations of Monitors

The Appendix provides a description of the provincial SP network (Table A-1).

Suspended particles were measured at 43 locations in 1990.

3.7 Monitoring Results

The distribution by percentile of the hourly data, the annual average, the maximum one-hour and 24-hour values, and the number of exceedances of the SP criteria (see Section 3.3) are provided in the Appendix (Table A-9).

The lowest levels measured in the province were at the CN Tower site (31190) in Toronto where the SP averaged 0.11 unit. This monitor is located 444 metres above ground. The lowest levels of SP (0.12 unit) measured at ground level were recorded at Cornwall (56051).

The greatest number of exceedances (33) of the 24-hour criterion and the highest annual mean (0.63 unit) occurred at the Mission site (31049), 381 Yonge Street, an urban street canyon in Toronto. The highest measured value (4.9 units) was at the Beach Boulevard site (29102) in Hamilton and at the Mission site (31049) in Toronto.

There were a total of 25 stations (60%) where the 24-hour criterion was exceeded at least once and three where the one-year criterion was exceeded. (See Table 1).

TRS

TOTAL REDUCED SULPHUR COMPOUNDS

4.1 Characteristics

The characteristics are mal odours similar to rotten eggs or rotten cabbage.

4.2 Effects

1 hour average	
less than 5 ppb	• no known effects
5 ppb	• odour threshold
27 ppb	• extremely odourous
1,000 ppb	• sensitive individuals may suffer nausea and headache due to severe odour

4.3 Ontario Criteria

Methyl Mercaptans - 10 ppb (1-hour)
Hydrogen Sulphide - 20 ppb (1-hour)
Total Reduced Sulphur (from Kraft Pulp Mills) - 27 ppb (1-hour)

4.4 Sources

The industrial sources include the steel industry, pulp and paper mills, and refineries and the natural sources include swamps, bogs, and marshes.

4.5 Method of Monitoring

Reduced sulphur compounds are oxidized to SO_2 in a high temperature converter and the SO_2 concentration is measured using fluorescent excitation by ultra-violet radiation.

4.6 Locations of Monitors

The Appendix provides a description of the provincial TRS compounds network (Table A-1).

TRS monitoring was carried out at 33 locations in 1990.

4.7 Monitoring Results

The distribution by percentile of the hourly data, the annual average, and the one-hour and 24-hour maxima are provided in the Appendix (Table A-11).

The lowest average levels measured in the province were at Tiverton (18007) on the western shore of Lake Huron. The highest annual mean (5.5 ppb) and the greatest number of exceedances (493) of the 1-hour TRS criterion were recorded at Fort Frances (62030) near a kraft paper mill. The highest 1-hour value (381 ppb) was measured at Terrace Bay (63093) also near a kraft paper mill (See Table 1).

CO

CARBON MONOXIDE

5.1 Characteristics

Colourless, odourless, tasteless gas which is produced as a result of incomplete combustion of carbonaceous fuels. It is of concern as an air pollutant because it has a strong affinity for haemoglobin and thus reduces the ability of blood to transport oxygen.

5.2 Effects

1 hour average	
less than 30 ppm	• no known effects
30 ppm	• increased cardiovascular symptoms for smokers with heart disease
50 ppm	• increasing cardiovascular symptoms for non-smokers with heart disease. Some visual impairment.

5.3 Ontario Criteria

30 ppm (1-hour)
13 ppm (8-hours)

5.4 Sources

The primary source of CO (about 80%) is motor vehicles. A secondary source is fossil fuel combustion for residential space heating and commercial/industrial operations.

5.5 Method of Monitoring

Non-dispersive infrared photometry based on the preferential absorption of infrared radiation by CO.

5.6 Locations of Monitors

The Appendix provides a description of the provincial CO network (Table A-1).

CO was monitored at 29 stations in 1990.

5.7 Monitoring Results

The distribution by percentile of the hourly data, the mean, and the maximum one-hour and eight-hour values are given in the Appendix (Table A-13).

The lowest annual average (0.3 ppm) was measured at Sarnia (14064) and North Bay (75010) while the highest annual average (1.9 ppm) was recorded at the Mission site (31049) at 381 Yonge Street in Toronto. The highest measured one-hour (18 ppm) and eight-hour (10 ppm) values were also recorded at the Mission site. This monitor is located in the Yonge Street corridor exposing it to motor vehicle exhaust.

There were no exceedances of the Ontario one-hour (30 ppm) or eight-hour (13 ppm) criteria during 1990. (See Table 1).

THC/RHC

HYDROCARBONS

6.1 Characteristics

Hydrocarbon compounds are primarily methane (colourless, odourless) which is present at about 1.5 ppm in the ambient atmosphere. Non-methane hydrocarbons (or reactive hydrocarbons) are usually present at much lower levels. This fraction reacts with nitrogen oxides in the presence of sunlight to form ozone.

6.2 Effects

Effects depend on the individual chemical species which the technique does not identify.

6.3 Ontario Criteria

None. However, criteria and standards exist for specific hydrocarbons and other organics.

6.4 Sources

Natural sources include trees and other vegetation and decay of animal and plant material.

Anthropogenic sources include motor vehicles, gasoline storage tanks, petroleum and chemical industries, landfill sites, paint manufacturing, application and fermentation sites.

6.5 Method of Monitoring

Calibrated flame ionization detector.

6.6 Locations of Monitors

The Appendix provides a description of the provincial THC/RHC network (Table A-1).

RHC was monitored at 4 stations while THC was monitored at 11 locations in 1990.

6.7 Monitoring Results

The distribution by percentile of the hourly data; the mean; and the maximum one-hour and 24-hour values are given in the Appendix (Tables A-15 and A-17).

The locations and values for the lowest, and highest means are given in Table 1. The highest one-hour maximum concentration (3.5 ppm) of reactive hydrocarbon compounds was measured at the Centennial Park monitor (14064) in Sarnia while the highest 1-hour total hydrocarbon value (20.0 ppm) for the year was measured at the Meadow Park site (46117) in Mississauga.

NO_2

NITROGEN DIOXIDE

7.1 Characteristics

NO_2 is a reddish-brown gas with a pungent and irritating odour over 0.10 ppm. It is an oxidation product of nitric oxide (NO) which is the primary NO_x emission. NO_2 reacts with hydrocarbons in sunlight to form ozone; and with water to form nitric acid, a component of acid rain.

7.2 Effects

1 hour average	
less than 0.10 ppm	• no known effects
0.10 ppm	• odour threshold
0.25 ppm	• some increase in bronchial reactivity in asthmatics
0.52 ppm	• increasing sensitivity to individuals with asthma and bronchitis

7.3 Ontario Criteria

0.20 ppm (1-hour)
0.10 ppm (24-hours)

7.4 Sources

Anthropogenic sources include high temperature combustion processes including automobiles, power plants, incinerators and several chemical processes. In Ontario, motorized transportation accounts for about 60% of total NO_x emissions.

Natural sources include lightning and soil bacteria.

7.5 Method of Monitoring

Monitoring for nitrogen compounds is based on the principle of chemiluminescence involving a gas phase reaction of NO with ozone. For NO_2, the sample stream is passed through a catalytic converter where NO_2 is reduced to NO.

7.6 Locations of Monitors

The Appendix provides a description of the provincial NO_2 network (Table A-1).

NO_2 monitoring was carried out at 38 locations in 1990.

7.7 Monitoring Results

The distribution by percentile of the hourly data, the annual average, and the maximum one-hour and 24-hour values are provided in the Appendix (Tables A-18). Also given are the number of exceedances of the nitrogen dioxide criteria (see Section 7.3).

The lowest levels measured in the province were at Simcoe (22071) in West Central Ontario where the arithmetic annual mean was 0.005 ppm. The highest annual mean (0.033 ppm) was measured in Toronto at the Mission site (31049) while the maximum 1-hour concentration (0.13 ppm) was measured at three sites in Toronto; East York (32010), North York West (34025) and York (36030).

There were no exceedances of the 1-hour (0.20 ppm) or 24-hour (0.10 ppm) criterion during 1990 (See Table 1).

NO

NITRIC OXIDE

8.1 Characteristics

NO is a colourless gas which oxidizes to NO_2 in the presence of hydrocarbons and sunlight.

8.2 Effects

No known direct effects on health or vegetation at ambient levels.

8.3 Ontario Criteria

None

8.4 Sources

Same as for NO_2.

8.5 Method of Monitoring

Same as for NO_2.

8.6 Locations of Monitoring

Same as for NO_2.

8.7 Monitoring Results

Several rural sites, i.e., Parkhill (15013), Simcoe (22071), Nanticoke (22086) and Long Point (22901) had the lowest annual means (0.001 ppm) and the Mission site (31049) in Toronto the highest (0.066 ppm). (See Appendix Table A-20 for the data summaries.)

NO_X

TOTAL NITROGEN OXIDES

NO_x is assumed to be the sum of NO_2 and NO concentrations in the atmosphere (in parts per million). (See Appendix Table A-22 for the data summaries.)

O_3

OZONE

10.1 Characteristics

Ozone is a colourless gas and a major component of photochemical oxidant compounds formed as the result of chemical reactions between nitrogen oxides and reactive hydrocarbons in the presence of sunlight.

10.2 Effects

1 hour average	
less than 50 ppb	• no known effects
80 ppb	• injurious to many species of vegetation
120 ppb	• decreasing performance by athletes exercising heavily
200 ppb	• decrease in lung function in exercising subjects, eye irritation

10.3 Ontario Criteria

80 ppb (1-hour)

10.4 Sources

Ozone is produced by photochemical reactions and is not directly emitted into the atmosphere in significant amounts. Since it is formed downwind of nitrogen oxide and hydrocarbon sources and is capable of travelling long distances through the atmosphere, ozone is a manifestation of the long range transport of air pollution and a component of smog. Its formation and transport are dependent on meteorological factors. Warm temperatures are critical and elevated concentrations generally occur from May to September between noon and early evening. While the naturally occurring ozone in the stratosphere is beneficial to life by shielding the earth from harmful ultra-violet (U.V.) radiation given off by the sun, high concentrations of ozone at ground level are a major health and environmental concern.

10.5 Method of Monitoring

Chemiluminescence emission spectroscopy and U.V. absorption photometry methods are used to monitor for ozone.

In the first method, an air sample reacts with ethylene to emit visible light (chemiluminescence) of intensity directly proportional to the ozone concentration. In the second method, ozone absorption of U.V. light changes the intensity of the U.V. light beam, which is attenuated in proportion to the concentration of the ozone.

10.6 Location of Monitors

The Appendix provides a description of the provincial O_3 network (Table A-1).

Ozone monitoring was carried out at 49 locations in 1990.

10.7 Monitoring Results

The distribution by percentile of the hourly data, the mean, and the maximum one-hour and 24-hour values are provided in the Appendix (Table A-23). Also given are the number of exceedances of the ozone criterion (see Section 10.3).

The lowest levels measured in the province were at the Science Centre (34002) in North York where the annual mean was 13.3 ppb.

The highest annual mean concentration (33.3 ppb) and the maximum 1-hour averaged concentration (130 ppb) were measured at Long Point Provincial Park (22901). The 1-hour criterion was exceeded at 45 out of 49 ozone stations (92%) during 1990. The greatest number of exceedances (173) occurred at the CN Tower (31190) where the height of the monitor is 444 metres. Concentrations aloft are generally higher than those at ground level and during the night they are decoupled from the ground by the nocturnal inversion (See Table 1).

TABLE 1 - HIGHLIGHTS OF THE CONTINUOUS MONITORING NETWORK 1990

	SO_2	SP	TRS	CO	THC	NO_2	NO	O_3
LOWEST MEAN LOCATION	THUNDER BAY (63200)	TORONTO (31190)	TIVERTON (18007)	SARNIA (14064) NORTH BAY (75010)	MISSISSAUGA (46117)	SIMCOE (22071)	SEVERAL	NORTH YORK (34002)
CONCENTRATION	0.0 ppm	0.11 UNIT	0.0 ppb	0.3 ppm	1.59 ppm	0.005 ppm	0.001 ppm	13.3 ppb
HIGHEST MEAN LOCATION	COPPER CLIFF (77218)	TORONTO (31049)	FORT FRANCES (62030)	TORONTO (31049)	TORONTO (31120)	TORONTO (31049)	TORONTO (31049)	LONG POINT (22901)
CONCENTRATION	0.020 ppm	0.63 UNIT	5.5 ppb	1.9 ppm	2.06 ppm	0.033 ppm	0.066 ppm	33.3 ppb
MOST CRITERION EXCEEDANCES - 1HR LOCATION	COPPER CLIFF (77218)	N/A	FORT FRANCES (62030)	-	N/A	-	N/A	TORONTO (31190)
NUMBER	149		493*	0		0		173
MOST CRITERION EXCEEDANCES - 24 HR LOCATION	COPPER CLIFF (77218)	TORONTO (31049)	N/A	N/A	N/A	-	N/A	N/A
NUMBER	13	33				0		
NO. OF STATIONS EXCEEDING 1 HR AQC NUMBER	17	N/A	23	0	N/A	0	N/A	45
NO. OF STATIONS EXCEEDING 24 HR AQC NUMBER	15	25	N/A	N/A	N/A	0	N/A	N/A
HIGHEST MEASURED VALUE - 1HR LOCATION	SUDBURY (77201)	TORONTO (31049) HAMILTON (29102)	TERRACE BAY (63093)	TORONTO (31049)	MISSISSAUGA (46117)	EAST YORK (32010) NORTH YORK WEST (34025) YORK (36030)	OSHAWA (45025)	LONG POINT (22901)
CONCENTRATION	1.20 ppm	4.9 UNIT	381.0 ppb	18.0 ppm	20.0 ppm	0.13 ppm	0.74 ppm	130.0 ppb
TOTAL NUMBER OF STATIONS NUMBER	75	43	33	29	11	38	38	49

* Exceedances of pulp mill criterion of 27 ppb for 1-hour.

SECTION C - AIR QUALITY INDEX

11.1 Characteristics

The Air Quality Index (AQI) is a real-time information system that provides the public with an indication of air quality at 34 sites in 27 major cities across Ontario. The system has been in operation since June 1988. The AQI is derived from the sub-indices which are calculated for the pollutants that have evidence of adverse effects on the environment. These pollutants are sulphur dioxide, ozone, nitrogen dioxide, total reduced sulphur, carbon monoxide and suspended particles. In addition, the API (Section 12.0) is also included as one of the AQI sub-indices along with the eight-hour average of CO. It should be noted that not all parameters are measured at all AQI sites. The AQI is provided to the public eight times daily and it is increased to hourly releases when the index reaches 32, the level at which air quality is described as moderate.

11.2 Effect

The AQI sub-index is calculated on a hourly basis for each pollutant. The sub-index increases as the air quality deteriorates. The index values, the corresponding categories and the health and environmental effects are given in Table 2. The highest sub-index at the given time becomes the AQI.

If the index value reaches 50 - 99, the air quality may have adverse effect on the most sensitive of the human or animal population, or may cause significant damage to vegetation, property, or aesthetic value. An AQI value of 100 or greater may cause adverse effects on the health of a large sector of the exposed population.

11.3 Operation of the System

In 1990, there were 34 AQI monitoring sites in Ontario. The larger cities have more than one AQI station (See Map 3 in Appendix). The cities are selected according to population and previous air quality history. The data from the 34 AQI stations are accessed on a real-time basis by the computer center at the Air Resources Branch. The computed indicies are released to the public, and the news media 8 times daily. In addition, AQI forecasts based on the meteorological conditions are issued four times daily. In the event that one of the AQI stations has an index greater than or equal to 32, the AQI information will be released hourly until it drops below 32.

11.4 Air Quality Index Levels (1990)

The frequency distribution of the hourly AQI, according to descriptive category, and according to the pollutant responsible for AQI $\geq$ 32 is shown for the thirty-four AQI monitoring locations across Ontario in Table 3. From this table, it is evident that at the majority of sites, ozone and suspended particles were the most frequent cause of elevated index readings. SO_2 and the API were the most frequent cause of elevated AQI in Sudbury (77203). Total reduced sulphur compounds were the most frequent cause of high indices in Cornwall (56051), Fort Frances (62030) and at Windsor College (12016). Very poor air quality was not reported at any of the AQI sites in 1990.

The total number of hours of moderate/poor air quality (see Figure 2) and the number of days on which the AQI was in the moderate/poor range for at least one hour at each AQI site is shown in Table 4. From this table it should be noted that during 1990 Fort Frances (62030) recorded at least one hour of moderate/poor air quality on approximately 56 percent of the monitoring days; at Cornwall (56051) on 26 percent of the days; Windsor College (12016) on 16 percent of the days; Hamilton West (29118) on 10 percent of the days; Sudbury (77203) on 6 percent of the days and finally, Waterloo (26045) recorded the lowest percentage of days of moderate/poor air quality - less than 1 percent.

TABLE 2 - AIR QUALITY INDEX POLLUTANTS AND THEIR IMPACT

INDEX	CATEGORY	CARBON MONOXIDE CO	NITROGEN DIOXIDE NO_2	OZONE O_3	SULPHUR DIOXIDE SO_2	SUSPENDED PARTICLES SP	SO_2 + SP (AS MEASURED BY THE API)	TOTAL REDUCED SULPHUR TRS
100-over	Very poor	Increasing cardiovascular symptoms in non smokers with heart disease some visual impairment	Increasing sensitivity of patients with asthma and bronchitis	Light exercise produces respiratory effects in patients with chronic pulmonary disease	Increasing sensitivity in patients with asthma and bronchitis	Increasing sensitivity in patients with asthma and bronchitis	Significant respiratory effects in patients with asthma and bronchitis	Sensitive individuals may suffer nausea and headaches due to severe odour
50-99	Poor	Increased cardiovascular symptoms in smokers with heart disease	Odour and discoloration. Some increase in bronchial reactivity in asthmatics	Decreasing performance by athletes exercising heavily	Odourous increasing vegetation damage	Visibility decreased soiling evident	Increased symptoms in patients with chronic respiratory disease	Extremely odourous
32-49	Moderate	Blood chemistry but no detectable impairment	Odourous	Injurious to many vegetation species eg. white beans tomatoes etc.	Injurious to some species of vegetation	Some decrease in visibility	Injurious to vegetation to sulphur dioxide	Odourous
16-31	Good	No effects	Slight odour	Injurious to some vegetation species in combination with SO_2 (4 hrs)	Injurious to some vegetation species in combination with ozone (4 hrs)	No effects	No effects	Slight odourous
0-15	Very good	No effects	No effects	No effects	No effects	No effects	No effects	No effects

TABLE 3: AIR QUALITY INDEX SUMMARY (1990)

		NUMBER OF HOURS AQI IN RANGE					# OF HOURS POLLUTANT RESPONSIBLE FOR AQI≥32						
Stn ID	CITY NAME	V-GOOD 0-15	GOOD 16-31	MOD 32-49	POOR 50-99	V-POOR 100+	SO_2	SP	O_3	TRS	CO	API	NO_2
44008	BURLINGTON	6248	2321	171	3	0	0	109	47	X	0	18	0
56051	CORNWALL	7309	1184	207	60	0	1	0	2	264	0	0	0
32010	EAST YORK	7210	1464	85	1	0	0	81	5	X	0	10	0
35003	ETOBICOKE WEST	7416	1274	70	0	0	0	50	20	X	0	0	0
35033	ETOBICOKE SOUTH	6832	1832	96	0	0	0	90	6	X	0	0	0
62030	FORT FRANCES *	6671	563	868	493	0	X	X	X	1361	X	X	X
28028	GUELPH	8053	602	52	0	0	0	0	52	X	X	0	X
29000	HAMILTON DOWNTOWN	7078	1523	145	1	0	0	65	19	14	0	48	0
29105	HAMILTON EAST	7808	875	51	0	0	0	18	33	0	X	0	X
29114	HAMILTON MOUNTAIN	7664	987	109	0	0	0	21	60	18	X	10	0
29118	HAMILTON WEST	7128	1517	115	0	0	0	58	41	14	X	2	0
26029	KITCHENER[2]	4126	263	15	0	0	0	0	15	X	0	0	0
26060	KITCHENER[2]	4024	274	22	0	0	0	2	20	X	0	0	0
52020	KINGSTON +	7346	532	75	1	0	X	X	76	X	X	X	X
15001	LONDON	7855	844	46	0	0	0	12	34	X	0	0	0
46110	MISSISSAUGA	8048	668	43	0	0	0	14	29	X	0	0	0
27056	NIAGARA FALLS	7795	855	93	0	0	0	0	93	X	X	0	X
34020	N. YORK CENTRAL	8017	715	28	0	0	0	5	23	X	0	0	0
34025	N. YORK WEST	6356	2242	152	0	0	0	140	8	X	0	4	0
75010	NORTH BAY	8051	574	17	0	0	0	5	12	X	0	0	0
44015	OAKVILLE	7493	1102	68	1	0	0	10	56	3	0	0	0
45025	OSHAWA	7654	1062	44	0	0	0	32	12	X	0	0	0
51001	OTTAWA	8021	700	23	0	0	0	21	2	X	0	0	0
14064	SARNIA	7597	1124	39	0	0	0	5	30	4	0	0	0
71068	SAULT STE MARIE	8103	565	41	2	0	0	31	6	6	X	0	0
33003	SCARBOROUGH	7743	975	30	0	0	0	17	13	X	0	0	0
27067	ST. CATHARINES	7955	756	49	0	0	0	5	44	X	0	0	0
77203	SUDBURY	8029	642	63	16	0	26	2	14	0	0	37	0
63200	THUNDER BAY	8509	233	18	0	0	0	16	0	2	0	0	0
31104	TORONTO DOWNTOWN[2]	6067	808	32	0	0	0	15	17	X	0	0	0
31103	TORONTO DOWNTOWN[2]	1724	73	3	0	0	0	3	0	X	0	0	0
31120	TORONTO WEST	7697	920	78	0	0	1	34	43	X	0	0	0
26045	WATERLOO	8293	461	6	0	0	0	2	4	X	X	0	X
12008	WINDSOR UNIVERSITY	7618	1080	61	1	0	0	29	33	X	0	0	0
12016	WINDSOR COLLEGE	7647	1000	105	3	0	0	31	21	56	0	0	0
36030	YORK	6865	1756	136	3	0	0	116	14	X	0	9	0

FOOTNOTES:

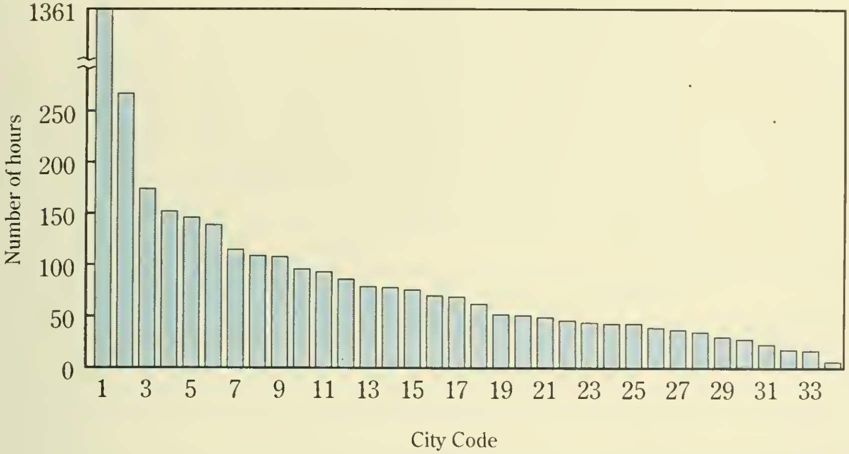
* FORT FRANCES - TRS ONLY POLLUTANT MONITORED.

+ KINGSTON - O_3 ONLY POLLUTANT MONITORED.

[2] STATION CHANGED LOCATION DURING 1990

X POLLUTANT NOT MONITORED AT STATION

Figure 2
Number of Hours of Unacceptable Air Quality at AQI Sites in Ontario (1990)



1. Fort Frances
2. Cornwall
3. Burlington
4. North York West
5. Hamilton Downtown
6. York
7. Hamilton West
8. Hamilton Mountain
9. Windsor - College
10. Etobicoke South
11. Niagara Falls
12. East York
13. Sudbury
14. Toronto West
15. Kingston
16. Etobicoke West
17. Oakville
18. Windsor - University
19. Guelph
20. Hamilton East
21. St. Catharines
22. London
23. Oshawa
24. Sault Ste Marie
25. Mississauga
26. Sarnia
27. Kitchener
28. Toronto Downtown
29. Scarborough
30. North York Central
31. Ottawa
32. Thunder Bay
33. North Bay
34. Waterloo

TABLE 4: NUMBER OF HOURS/DAYS OF UNACCEPTABLE AIR QUALITY AT AQI SITES (1990)

Station ID	City Name	# of hours AQI ≥ 32	# of Days at least 1 hour - AQI ≥ 32
44008	BURLINGTON	174	45
56051	CORNWALL	267	95
32010	EAST YORK	86	37
35003	ETOBICOKE WEST	70	31
35033	ETOBICOKE SOUTH	96	45
62030	FORT FRANCES *	1361	205
28028	GUELPH	52	15
29000	HAMILTON DOWNTOWN	146	32
29105	HAMILTON EAST	51	19
29114	HAMILTON MOUNTAIN	109	30
29118	HAMILTON WEST	115	35
26029	KITCHENER	37	14
52020	KINGSTON +	76	14
15001	LONDON	46	17
46110	MISSISSAUGA	43	18
27056	NIAGARA FALLS	93	21
34020	N. YORK WEST CENTRAL	28	9
34025	N. YORK WEST	152	47
75010	NORTH BAY	17	8
44015	OAKVILLE	69	18
45025	OSHAWA	44	24
51001	OTTAWA	23	10
14064	SARNIA	39	18
71068	SAULT STE MARIE	43	26
33003	SCARBOROUGH	30	19
27067	ST. CATHARINES	49	16
77203	SUDBURY	79	21
63200	THUNDER BAY	18	12
31104	TORONTO DOWNTOWN	35	15
31120	TORONTO WEST	78	31
26045	WATERLOO	6	3
12008	WINDSOR UNIVERSITY	62	22
12016	WINDSOR COLLEGE	108	55
36030	YORK	139	57

* FORT FRANCES - TRS ONLY POLLUTANT MONITORED
+ KINGSTON - O_3 ONLY POLLUTANT MONITORED

12.0 Air Pollution Index (API)

12.1 Characteristics

The API continues to be the basis of an alert and control system to warn of deteriorating air quality and is derived from 24-hour running averages of sulphur dioxide and suspended particles. Research studies have linked respiratory illness to elevated concentrations of sulphur dioxide and particulates.

12.2 Legislation

Regulation 308 under the the Ontario Environmental Protection Act (1971) authorizes the Minister of the Environment to order any point source not essential to public health or safety to curtail or cease its operations when air pollution levels which may be injurious to health occur.

12.3 Operation of the System

The API is computed each hour based on the past 24 hourly values for SO_2 and SP. If the index reaches a value of 32 and if the Duty Meteorologist predicts a continuation of adverse atmospheric conditions for at least six hours, an Air Pollution Advisory is issued. Owners of significant sources of pollution are advised to prepare for possible curtailment of operations.

If the index reaches 50, and if at least six hours of adverse atmospheric conditions are forecast, owners of major sources may be ordered to curtail operations. This is the First Alert Level.

A Second Alert is issued at an API of 75, and further curtailment may be ordered.

The Air Pollution Episode Threshold Level occurs at an API of 100. If atmospheric conditions are not expected to improve for at least six hours, owners of all sources not essential to public health or safety may be ordered to cease operations.

12.4 Air Pollution Index Levels (1981-1990)

A history of the Air Pollution Index levels over the last 10 years of its operation is provided in Table 5.

TABLE 5: ONTARIO'S AIR POLLUTION INDEX

YEAR	CITY	NUMBER OCCASIONS		MAXIMUM INDEX	DATE OF MAXIMUM
		≥32	≥50		
1981	TORONTO	3	0	43	Nov. 14
	HAMILTON	8	0	38	Nov. 15
	SUDBURY	0	0	21	Jan. 31
	WINDSOR (12008)	1	0	42	Nov. 17
	WINDSOR (12016)	0	0	31	Nov. 17
	NIAGARA FALLS	0	0	25	Jan. 14
	CONISTON	0	0	20	Nov. 25
	NEW SUDBURY	0	0	22	Jan. 28-29
	SARNIA	1	0	34	Feb. 16
	ST. CATHARINES	0	0	27	Jan. 14-15
1982	TORONTO	3	2	54	Oct. 27
	HAMILTON	12	0	39	Dec. 2
	SUDBURY	0	0	15	Feb. 3
	WINDSOR (12008)	0	0	31	Oct. 26-27
	WINDSOR (12016)	1	0	35	Oct. 27
	NIAGARA FALLS	0	0	19	Jan. 19
	CONISTON	1	0	39	Feb. 5
	NEW SUDBURY	0	0	29	Feb. 5
	SARNIA	0	0	27	Mar. 11, Nov. 7-8
	ST. CATHARINES	0	0	31	Nov. 18
1983	TORONTO	3	0	39	Jan. 29
	HAMILTON	1	0	37	Mar. 2
	SUDBURY	1	0	39	Jan. 22
	WINDSOR (12008)	0	0	26	Sep. 27
	WINDSOR (12016)	1	0	33	Mar. 1-2
	NIAGARA FALLS	0	0	17	Jan. 30
	CONISTON	0	0	19	Jan. 15
	NEW SUDBURY	1	1	63	Jan. 22
	SARNIA	0	0	28	Jan. 29
	ST. CATHARINES	0	0	23	Jan. 30
1984	TORONTO	2	1	50	Jan. 16
	HAMILTON	8	0	44	Nov. 27
	SUDBURY	0	0	23	Feb. 1
	WINDSOR (12008)	0	0	31	Oct. 2, Nov. 14
	WINDSOR (12016)	1	0	40	Feb. 15
	NIAGARA FALLS	0	0	20	Dec. 10-11
	CONISTON	0	0	29	Nov. 22
	NEW SUDBURY	0	0	23	Nov. 22
	SARNIA	0	0	27	Jan. 23
	ST. CATHARINES	0	0	24	Feb. 10-11

YEAR	CITY	NUMBER OCCASIONS ≥32	≥50	MAXIMUM INDEX	DATE OF MAXIMUM
1985	TORONTO	0	0	25	Apr. 23
	HAMILTON	2	0	36	Apr. 23-24
	SUDBURY	0	0	31	Aug. 4
	WINDSOR (12008)	0	0	25	Dec. 20
	WINDSOR (12016)	0	0	30	Dec. 20
	NIAGARA FALLS	0	0	19	Apr. 24
	CONISTON	0	0	19	Mar. 26
	NEW SUDBURY	0	0	31	Jan. 7
	SARNIA	0	0	20	Mar. 27-28
	ST. CATHARINES	0	0	18	Dec. 6
1986	TORONTO	0	0	22	Jan. 17
	HAMILTON	5	0	37	May 15
	SUDBURY	0	0	23	Oct. 26
	WINDSOR (12008)	0	0	31	Jan. 16, Oct. 22, Dec. 16
	WINDSOR (12016)	0	0	29	Mar. 14
	NIAGARA FALLS	0	0	17	Jan. 17
	CONISTON	0	0	18	Mar. 20-21
	NEW SUDBURY	0	0	20	Apr. 23
	SARNIA	0	0	29	Dec. 17
	ST. CATHARINES	0	0	18	Jan. 17
1987	TORONTO	0	0	31	Oct. 16
	HAMILTON	2	0	38	Oct. 17
	SUDBURY	0	0	26	Mar. 14
	WINDSOR (12008)	0	0	24	Apr. 10
	WINDSOR (12016)	0	0	2	Jun. 25, Oct. 24
	NIAGARA FALLS	0	0	16	Oct. 16-17
	CONISTON	0	0	23	Mar. 9, Mar. 11
	NEW SUDBURY	0	0	22	Mar. 11, Mar.14, Aug. 27
	SARNIA	0	0	24	Jan. 28
	ST. CATHARINES	0	0	24	Oct. 16-17
1988	TORONTO DOWNTOWN	0	0	22	Jul. 7
	HAMILTON DOWNTOWN	1	0	43	Nov. 25-26
	SUDBURY	0	0	25	Jun. 17-18
	WINDSOR (12008)	0	0	28	Nov. 23, Dec.7
	WINDSOR (12016)	0	0	24	Jan. 8-9
	NIAGARA FALLS	0	0	20	Nov. 26
	#CONISTON	0	0	21	Apr. 19
	#NEW SUDBURY	0	0	21	Jun. 15
	SARNIA	0	0	26	Jan. 30
	ST. CATHARINES	0	0	14	Jul. 31
	*TORONTO WEST	0	0	13	Dec. 13
	*EAST YORK	0	0	22	Nov. 4
	*SCARBOROUGH	0	0	29	Sep. 30
	*NORTH YORK CENTRAL	0	0	23	Nov. 26
	*NORTH YORK WEST	0	0	27	Nov. 26
	*ETOBICOKE WEST	1	0	33	Nov. 26
	*ETOBICOKE SOUTH	0	0	29	Nov. 26

YEAR	CITY	NUMBER OCCASIONS		MAXIMUM INDEX	DATE OF MAXIMUM
		≥32	≥50		
1988 Cont'd	*YORK	0	0	29	Nov. 26
	*BURLINGTON	0	0	27	Sep. 8-9
	*OAKVILLE	0	0	24	Sep. 2
	*OSHAWA	0	0	23	Jun. 15, Jul. 7
	*MISSISSAUGA	0	0	18	Jul. 19
	*LONDON	0	0	22	Nov. 26
	*KITCHENER	0	0	26	Aug. 2
	*WATERLOO	0	0	17	Nov. 25-26
	*GUELPH	0	0	18	Nov. 26
	*HAMILTON EAST	0	0	20	Nov. 26
	*HAMILTON MOUNTAIN	0	0	23	Nov. 26
	*HAMILTON WEST	0	0	26	Nov. 25-26
	*SAULT STE MARIE	0	0	24	Jun. 20
	*NORTH BAY	0	0	16	Nov. 26
	*OTTAWA	0	0	18	Aug. 5, Dec. 19-20
	*CORNWALL	0	0	20	Jun. 7
	*THUNDER BAY	0	0	5	Nov. 24-25
1989	TORONTO DOWNTOWN	0	0	28	Oct. 26
	HAMILTON DOWNTOWN	3	0	37	Oct. 30-31
	SUDBURY	0	0	24	Sep. 14
	WINDSOR (12008)	0	0	27	Oct. 27
	WINDSOR (12016)	1	0	32	Oct. 27
	NIAGARA FALLS	0	0	21	Oct. 29
	SARNIA	0	0	26	Oct. 27-28
	ST. CATHARINES	0	0	18	Mar. 10
	TORONTO WEST	1	0	33	Oct. 26
	EAST YORK	1	0	34	Oct. 26
	SCARBOROUGH	1	0	34	Oct. 26
	NORTH YORK CENTRAL	0	0	26	Oct. 26
	NORTH YORK WEST	1	0	38	Dec. 27
	ETOBICOKE WEST	0	0	29	Oct. 26
	ETOBICOKE SOUTH	2	0	33	Oct. 26
	YORK	2	0	38	Oct. 26
	BURLINGTON	1	0	34	Aug. 12
	OAKVILLE	0	0	27	Oct. 26
	OSHAWA	0	0	29	Oct. 27-28
	MISSISSAUGA	1	0	35	Oct. 26
	LONDON	1	0	32	Oct. 27
	WATERLOO	0	0	19	Aug. 12
	GUELPH	0	0	19	Oct. 27-28
	HAMILTON EAST	0	0	24	Oct. 31
	HAMILTON MOUNTAIN	0	0	22	Oct. 28-29
	HAMILTON WEST	0	0	29	Oct. 31
	SAULT STE MARIE	0	0	24	Sep. 14
	NORTH BAY	0	0	19	Jan. 24, Feb. 17
	OTTAWA	0	0	27	Jan. 24
	CORNWALL	0	0	19	Feb. 18

YEAR	CITY	NUMBER OCCASIONS ≥32	≥50	MAXIMUM INDEX	DATE OF MAXIMUM
1990	TORONTO DOWNTOWN	0	0	25	Nov. 16
	HAMILTON DOWNTOWN	2	0	42	Mar. 16
	SUDBURY	2	0	42	Oct. 24
	WINDSOR (12008)	0	0	26	Nov. 20
	WINDSOR (12016)	0	0	21	Nov. 20-21
	NIAGARA FALLS	0	0	18	Mar. 9-10
	SARNIA	0	0	27	Jan. 14
	ST. CATHARINES	0	0	22	Nov. 21
	TORONTO WEST	0	0	26	Mar. 16
	EAST YORK	0	0	27	Sept.27
	SCARBOROUGH	0	0	23	Jan. 16
	NORTH YORK CENTRAL	0	0	20	Feb. 22, Mar. 16
	NORTH YORK WEST	1	0	32	Mar. 15
	ETOBICOKE WEST	0	0	27	Aug. 10
	ETOBICOKE SOUTH	0	0	27	Mar. 16
	YORK	1	0	33	Mar. 15,16
	BURLINGTON	2	0	34	May. 14
	OAKVILLE	0	0	21	Aug. 10
	OSHAWA	0	0	23	Mar. 15, Nov. 30
	MISSISSAUGA	0	0	24	Feb. 22
	LONDON	0	0	27	Nov. 20-21
	WATERLOO	0	0	18	Nov. 21
	GUELPH	0	0	15	Nov. 2
	HAMILTON EAST	0	0	27	Mar. 16
	HAMILTON MOUNTAIN	1	0	38	Mar. 16
	HAMILTON WEST	1	0	32	Mar. 16
	SAULT STE MARIE	0	0	23	Jan. 16
	NORTH BAY	0	0	17	Jun. 14
	OTTAWA	0	0	26	Jan. 17
	CORNWALL	0	0	15	Jan. 17

* started June, 1988
# closed May, 1988

13.0 Lambton Industrial Meteorological Alert (LIMA)

The Lambton Industrial Meteorological Alert System (LIMA) is part of the Environmental Protection Act - Reg. 151/81. The application of this alert is limited to that part of the county of Lambton bounded by Lake Huron, the St. Clair River, the King's Highway known as No. 80, the roadway known as Moore Township Road 31 and its continuation through that part of the King's Highway known as No. 40 and Lambton County road 27, which includes the City of Sarnia.

The Minister may declare an Alert when the twenty-four hour running average sulphur dioxide concentration at any station in the Lambton Industrial Meteorological Alert system reaches 0.07 ppm and meteorological forecasts indicate a continuation for six hours or more of weather conditions conducive to elevated sulphur dioxide concentrations.

The monitoring stations are at Front Street, Centennial Park, and River Bend in Sarnia and Port Huron in Michigan.

During 1990 the alert was issued on nine occasions. The longest duration of the alert was 21 hours lasting from 1600 EST on January 3, 1990 to 1300 EST January 4, 1990. The maximum 24-hour running average sulphur dioxide concentration during this episode reached 0.102 ppm and was recorded at the Front Street monitoring site. The highest 24-hour running average sulphur dioxide concentration recorded during 1990 was 0.111 ppm and was recorded at Front Street on November 15, 1990.

TABLE 6: LAMBTON INDUSTRIAL METEOROLOGICAL ALERT SUMMARY 1981-1990

Year	Alerts Called	Average Duration (Hours)
1981	12	18
1982	13	14
1983	5	18
1984	7	15
1985	3	16
1986	8	14
1987	0	-
1988	5	24
1989	3	12
1990	9	16

On four other occasions the LIMA reached 0.07 ppm but the alert was not issued since the meteorological conditions were not conducive for the build up of sulphur dioxide concentrations.

Three LIMA alerts for Centennial Park were simultaneously issued with three of the twelve alerts issued for Front Street.

The number of LIMA alerts called over the past 10 years is displayed in Table 6.

SECTION D - POLLUTANTS MEASURED BY HIGH VOLUME SAMPLER MONITORING (DAILY DATA)

TSP

TOTAL SUSPENDED PARTICULATES

14.1 Characteristics

Total suspended particulate is a generic term for airborne particles including smoke, fume, dust, fly ash and pollen. Composition varies with place and season but normally includes soil particulates, organic matter, sulphur and nitrogen compounds and metals such as lead. Size range is approximately 0.1 to 100 microns (diameter).

14.2 Effects

The greatest impact on health is from particles less than 10 microns in diameter which can penetrate deep into the lungs and contribute to respiratory disease (see Section 15.1). More serious health effects may be associated with suspended particulate matter which contains a toxic particulate component or which has absorbed a gaseous pollutant on the surface of the particles. Corrosion, soiling, damage to vegetation and visibility reduction are additional effects.

14.3 Ontario Criteria

120 $\mu g/m^3$ (24-hours)
60 $\mu g/m^3$ (1-year - geometric mean)

14.4 Sources

Natural sources of TSP include wind-blown soil, forest fires and plant pollen. Anthropogenic sources include combustion, incineration, construction, mining, metals smelting and processing, grinding processes, agricultural activity and transportation.

14.5 Method of Monitoring

TSP is measured by an instrument called a High Volume Sampler. Air is drawn through a filter at the rate of approximately 1.4 m^3/min. The (daily) mass concentration of total suspended particulate matter is computed from the mass of collected particles and the volume of air sampled.

14.6 Location and Frequency of Monitoring

The monitoring locations and the frequency of sampling at each location are indicated in the Appendix (Table A-3).

TSP was measured at 139 locations in 1990.

14.7 Monitoring Results

The distribution by percentile, the maximum, the arithmetic mean and the geometric mean are given in the Appendix (Table A-25). Also given are the number of exceedances of the 24-hour and one-year criteria. The lowest levels measured in the province were at Dorset (49010) where the annual mean was 19 $\mu g/m^3$.

The highest annual geometric mean (85 $\mu g/m^3$) was recorded at Niagara Falls (27055) while the maximum daily value (600 $\mu g/m^3$) was measured near a sawmill in Hearst (72080). The greatest percentage of exceedances (28) of the 24-hour criterion occurred at Windsor (12013). The Stanley Avenue monitor (27055) in Niagara Falls and the Church Street monitor (62035) in Fort Frances were close seconds, recording exceedances 27 percent of the time.

There were a total of 86 stations which exceeded the 24-hour criterion and 19 which exceeded the one-year criterion. (See Table 8).

IP

INHALABLE PARTICULATE

15.1 Characteristics

The term PM-10 fraction has been given to the fraction of the total suspended particulate which have a diameter of 10 um or less. This has been determined to be the particle size which is most likely to be inhaled and deposited into the thoracic region of the lung.

15.2 Effects

IP effects are on pulmonary function, aggravation of existing pulmonary and cardiovascular disease, mucociliary clearance and other host mechanisms. Corrosion, soiling, damage to vegetation and visibility reduction are additional effects.

TABLE 7: COMPARISON OF INHALABLE PARTICULATE (IP) VERSUS TOTAL SUSPENDED PARTICULATE (TSP) (JULY 1989 TO JAN 1991)

	N	Mean IP	Mean TSP	Max IP	Max TSP	% IP of TSP	IP=A+B(TSP)	r
Windsor	79	30.8	60.6	84	150	51	IP=.6+.50(TSP)	.80
Hamilton	49	36.2	83.4	97	220	43	IP=.1+.43(TSP)	.84
Toronto	67	28.5	59.5	110	176	48	IP=4.7+.38(TSP)	.67
Sault Ste Marie	68	50.7	96.7	190	400	52	IP=9.1+.45(TSP)	.94
Thunder Bay	86	20.3	38.1	63	108	53	IP=2.0+.50(TSP)	.82

N = number of data points
r = correlation coefficient
units are in $\mu g/m^3$
IP is measured by PM-10 sampler

15.3 Ontario Criteria

None.

15.4 Sources

Same as for TSP.

15.5 Method of Monitoring

IP is monitored by a modified hi-volume sampler outfitted with a size selective inlet to restrict particle size to less than 10 um. The daily mass of the inhalable particulate is computed from the mass of the collected particles and the volume of air sampled. Quartz filters are used as the filter medium for collection.

15.6 Location and Frequency of Monitoring

PM-10 monitoring locations are shown in the Appendix, Map 8. All sites operated on a 6-day sampling schedule. Monitoring for PM- 10 began in mid 1989 and completed its first full year of measurements at five sites in 1990. During late 1990, the PM-10 network expanded to thirteen sites with a proposed further expansion to 20 sites by 1991.

15.7 Monitoring Results

The distribution by percentile, the maximum, the arithmetic mean and the geometric mean are given in the Appendix, (Table A-27), for inhalable particulate as well as for lead and selected inhalable trace metals such as chromium, vanadium, copper, iron, manganese and nickel. There are presently no criteria for these trace metals in inhalable particulate.

For the inhalable particulate, the highest annual arithmetic mean (40 $\mu g/m^3$) and the maximum daily value (130 $\mu g/m^3$) were recorded at the Bonney Street (71342) monitor in Sault Ste Marie.

A comparison of inhalable particulate versus total suspended particulate was done for all data collected during the period July 1989 through to January 1991. Table 7 shows the distribution of this data set including the number of samples, the mean and maximum recorded values of IP and TSP, the percentage IP is of the TSP loading, the linear equation expressing IP in terms of TSP and the corresponding r value. IP varies from 43 percent of the TSP loading at Hamilton to 53 percent of the total loading at Thunder Bay.

Pb

LEAD IN TOTAL SUSPENDED PARTICULATE

16.1 Characteristics

Lead is a silver bluish, white, soft metal with a molecular of weight 207.20.

16.2 Effects

Lead can degrade renal function, impair haemoglobin synthesis, and alter the nervous system.

16.3 Ontario Criteria

5.0 $\mu g/m^3$ (24-hours)
2.0 $\mu g/m^3$ (30-day - geometric mean)

16.4 Sources

Lead sources include combustion of gasoline containing lead additives, secondary smelting of lead, battery manufacturing, metal fabrication, some paint and glass manufacturing, production of iron, steel, copper and nickel. Lead emissions fell significantly after 1975 with the introduction of lead-free gasoline.

16.5 Method of Monitoring

The lead concentration on high volume filters is analyzed by either X-Ray fluorescence or atomic absorption.

16.6 Location and Frequency of Monitoring

The monitoring locations and sampling frequency for each location are indicated in the Appendix (Table A-3). Lead was measured at 84 locations in 1990.

16.7 Monitoring Results

The distribution by percentile, the maximum, the arithmetic mean and the geometric mean are given in the Appendix (Table A-28).

Also given are the number of exceedances of the 24-hour criterion.

The greatest percentage of exceedances of the 24-hour criterion occurred at the Dixie Road monitor (46041) in Mississauga and at the Eastern Avenue monitor (31065) in Toronto. Both monitoring sites are located in the vicinity of lead processing plants.

The highest annual geometric mean (0.61 μg/m^3) was recorded at station 46041 in Mississauga while the maximum 24-hour concentration (29.56 μg/m^3) occurred at station 31065 in Toronto.

There were a total of 5 stations which exceeded the daily criterion at least once (see Table 8).

TRACE METALS

CADMIUM, CHROMIUM, IRON, MANGANESE, NICKEL, VANADIUM, COPPER

17.1 Characteristics

Name	Symbol	Properties	Molecular Weight
Cadmium	Cd	silver white, hexagonal	112.41
Chromium	Cr	steel grey, cubic	52.00
Iron	Fe	silver, cubic	58.85
Manganese	Mn	grey-pink, cubic	54.94
Nickel	Ni	silver, cubic	58.60
Vanadium	V	light grey, cubic	50.94
Copper	Cu	red, cubic	63.55

17.2 Effects

The depth of penetration into the respiratory system (and consequently risk to health) increases as particle size decreases. Of the heavy metals, cadmium, chromium, vanadium and manganese probably pose the greatest risk to human health. Soiling and damage to vegetation are additional effects.

17.3 Ontario Criteria

	24 Hour Criterion
Cadmium	2 μg/m^3
Chromium	1.5 μg/m^3
Manganese	2.5 μg/m^3
Nickel	2 μg/m^3
Vanadium	2 μg/m^3
Copper	50 μg/m^3

17.4 Sources

See Section 14.4.

17.5 Method of Monitoring

The collection method is by High Volume Sampler (see Section 14.5). Following determination of TSP, a portion is cut from the exposed filter and ashed to destroy carbonaceous matter. The ashed sample is then digested in acid, and analyzed by atomic absorption spectrophotometry. The mass concentration of each metal in ambient air is calculated from the mass of each metal in TSP and the volume of air sampled, and expressed in $\mu g/m^3$.

17.6 Location and Frequency of Sampling

The monitoring locations and the sampling frequency for each location are indicated in the Appendix (Table A-3).

Metals were measured at 53 to 58 stations depending on the element.

17.7 Monitoring Results

The distribution by percentile of the daily data, the maximum, the arithmetic mean, the geometric mean, and the number of exceedances of the daily criterion are provided in the Appendix for cadmium, chromium, iron, manganese, nickel, vanadium and copper. Table A-40 shows the maximum monitored levels for all the trace metals listed above. No table is provided for cobalt because a large percentage of the values are below the detection limit.

Table 8 provides the highlights of particulate monitoring for 1990. It shows that one exceedance of the air quality criteria for metals (exclusive of lead) occurred in 1990. The exceedance occurred at Sault Ste Marie (71042) and manganese was the metal responsible. Such exceedances may have an adverse effect on human health.

NO_3^-

NITRATE

18.1 Characteristics

Nitrogen oxide compounds are formed from atmospheric nitrogen and oxygen through high temperature combustion, photochemical reactions or bacterial action and may react with other compounds in the air to form nitrate (NO_3^-) or nitric acid (HNO_3).

18.2 Effects

Nitrate and nitric acid are involved in corrosion of materials, visibility degradation and acidic precipitation. They may also have an adverse effect on human health.

18.3 Ontario Criteria

None

18.4 Sources

Nitrate is primarily a secondary pollutant. Anthropogenic sources of nitrogen oxides or nitrates include all high temperature combustion processes, transportation, and fertilizer production and usage. Natural sources include lightning, biological decomposition and photochemical reactions.

18.5 Method of Monitoring

Nitrates are collected on glass fibre filters by a High Volume Sampler and they are extracted by digestion in distilled water. This extract is reduced to nitrite followed by colourimetric analysis for determination of the mass concentration of atmospheric nitrate.

18.6 Location and Frequency of Monitoring

The monitoring locations and the length of the sampling cycle (in days) for each location are indicated in the Appendix (Table A-3).

Nitrate monitoring was carried out at 56 locations in 1990.

18.7 Monitoring Results

The distribution by percentile, the maximum, the arithmetic mean, and the geometric mean are given in the Appendix (Table A-41). Highlights of monitoring are summarized in Table 8.

The highest annual mean nitrate concentration (5.5 $\mu g/m^3$) occurred in Windsor (12008) and the highest concentration for a single day (38.1 $\mu g/m^3$) occurred in Toronto (31046).

SO_4^{2-}

SULPHATE

19.1 Characteristics

Sulphur dioxide is oxidized in the atmosphere to eventually form sulphate compounds. Intermediaries in the oxidation process such as H_2SO_3 and SO_3 rapidly combine with water vapour to form sulfuric acid aerosol. This type of process is dependent on atmospheric conditions.

19.2 Effects

Sulphate compounds have been linked to respiratory irritation and disease, corrosion of materials, reduction of visibility and the formation of acidic precipitation.

19.3 Ontario Criteria

None.

19.4 Sources

Sulphate is primarily a secondary pollutant. Anthropogenic sources of sulphur oxides include the burning of fuels containing sulphur (such as coal and oil), the smelting of sulphur containing ores and the refining of petroleum. Natural sources include bacterial decomposition, volcanoes and forest fires.

19.5 Method of Monitoring

Sulphate is collected on glass fibre filters by a High Volume Sampler and it is extracted by digestion in distilled water. This extract is analyzed colourimetrically and the mass concentration of sulphate is calculated. It has been found that artifact sulphates form on the glass fibre filters from ambient SO_2 and that reported sulphate concentrations are therefore artificially high. No attempt has been made to correct the data reported here.

19.6 Location and Frequency of Monitoring

The monitoring locations and the length of the sampling cycle (in days) for each location are indicated in the Appendix (Table A-3). Sulphate monitoring was carried out at 56 locations in 1990.

19.7 Monitoring Results

The distribution by percentile, the maximum, the arithmetic mean, and the geometric mean are given in the Appendix (Table A-43). Highlights of monitoring are summarized in Table 8.

The highest annual mean sulphate concentration (11.5 $\mu g/m^3$) was measured at Hamilton (29102) and the highest concentration (51.4 $\mu g/m^3$) for a single day occurred at Windsor (12015).

TABLE 8 - HIGHLIGHTS OF THE SUSPENDED PARTICULATE (HiVol) MONITORING NETWORK 1990

	TSP	IP	Pb	Cr	Fe	Mn	Ni	Cu	NO$_3^-$	SO$^{2-}_4$
LOWEST GEOM MEAN	DORSET	THUNDER BAY	SEVERAL	BEACHVILLE	SEVERAL	MOORETOWN	SEVERAL	SEVERAL	S.S.MARIE	S.S.MARIE
LOCATION	(49010)	(63201)		(17115)		(14031)			(71049)	(71049)
CONCENTRATION	19 ug/m^3	19 ug/m^3 *	0.01 ug/m^3	0.003 ug/m^3	0.2 ug/m^3	0.008 ug/m^3	0.003 ug/m^3	0.01 ug/m^3	0.8 ug/m^3	3.7 ug/m^3
HIGHEST GEOM MEAN	NIAGARA FALLS	S.S. MARIE	MISSISSAUGA	HAMILTON	WINDSOR	HAMILTON	COPPER CLIFF	COPPER CLIFF	WINDSOR	HAMILTON
LOCATION	(27055)	(71042)	(46041)	(29011)	(12038)	(29011)	(77070)	(77070)	(12008)	(29102)
CONCENTRATION	85 ug/m^3	40 ug/m^3 *	0.61 ug/m^3	0.021 ug/m^3	4.1 ug/m^3	0.257 ug/m^3	0.179 ug/m^3	0.31 ug/m^3	5.5 ug/m^3	11.5 ug/m^3
PERCENTAGE OF SAMPLES ABOVE 24-HR AQC LOCATION	WINDSOR (12013)	N/A	MISSISSAUGA (46041) TORONTO (31065)		N/A	HAMILTON (29025)	COPPER CLIFF (77070)		N/A	N/A
VALUE	28		2	0		0.3	0	0		
NO. OF STATIONS EXCEEDING 24-HR AQC NUMBER	86	N/A	5	0	N/A	1	0	0	N/A	N/A
NO. OF STATIONS EXCEEDING 1-YR AQC NUMBER	19	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
HIGHEST MEASURED VALUE - 24-HR	HEARST	S.S. MARIE	TORONTO	HAMILTON	S.S.MARIE	S.S. MARIE	COPPER CLIFF	SCHREIBER	TORONTO	WINDSOR
LOCATION	(72080)	(71042)	(31065)	(29025)	(71042)	(71042)	(77070)	(63401)	(31046)	(12015)
CONCENTRATION	600 ug/m^3	130 ug/m^3	29.56 ug/m^3	0.680 ug/m^3	97.1 ug/m^3	3.630 ug/m^3	1.20 ug/m^3	5.79 ug/m^3	38.1 ug/m^3	51.4 ug/m^3
TOTAL NUMBER OF STATIONS NUMBER	139	5	84	53	63	56	57	59	56	56

* Arithmetic mean

SECTION E - POLLUTANTS MEASURED BY DUSTFALL JAR AND FLUORIDE CANDLE (MONTHLY DATA)

TDF

TOTAL DUSTFALL

20.1 Characteristics

Total Dustfall is a measure of the amount of settleable particulate in the atmosphere. The larger, more visible fraction of the particulate matter will settle out more rapidly than the fine particulate. Composition varies with place and season but normally includes soil particulates, organic matter, sulphur and nitrogen compounds, metals and re-entrained road dust.

20.2 Effects

There are generally no health effects associated with total dustfall; however, adverse health effects may be associated with dustfall which contains a toxic component or which has absorbed a gaseous pollutant on the surface of the particles. Corrosion, soiling, damage to vegetation and visibility reduction are additional effects.

20.3 Ontario Criteria

7.0 g/m^2/30 days	(30 days)
4.6 g/m^2/30 days	(1-year arithmetic mean)

20.4 Sources

Same as TSP and SP (COH).

20.5 Method of Monitoring

Dustfall is collected by exposing an open top plastic jar for 30-days. The total amount of dustfall is determined by weighing the contents of the jar and expressing the results in g/m^2/30 days.

The settleable particulate collected in the dustfall jar can be separated into a soluble and insoluble fraction for further analysis. The insoluble portion can be examined using an optical microscope to determine the composition of the particulate. Total dustfall can be analyzed for metals and other compounds which are listed in Table A-5.

20.6 Location and Frequency of Monitoring

Dustfall was measured at 208 locations throughout the province in 1990. The monitoring locations are indicated in the Appendix (Table A-5).

20.7 Monitoring Results

The monthly values, the maximum, the geometric standard deviation and the arithmetic and geometric means are given in the Appendix (Table A-45).

The highest annual arithmetic mean (15.9 g/m^2/30 days) was recorded at station (29036) in the heart of Hamilton's industrial area while the highest monthly value (59.2 g/m^2/30 days) was recorded in Sunderland (45074) in the vicinity of a fertilizer plant.

There were a total of 138 stations (66%) which exceeded the monthly (30-day) criterion and 86 stations (41%) which exceeded the 1-year criterion.

FLR

FLUORIDATION RATE

21.1 Characteristics

Fluoridation rate is a measurement designed to indicate relative amounts of gaseous fluorides present over an extended period of time.

21.2 Effects

On vegetation

21.3 Ontario Criteria

40 µg/100 cm^2/30 days
growing season:
(April 1 - October 31 for southern Ontario);
(May 1 - September 30 for northern Ontario)

80 µg/100 cm^2/30 days
non-growing season:
(November 1 - March 31 for southern Ontario);
(October 1 - April 30 for northern Ontario)

21.4 Sources

Anthropogenic sources include fossil fuel power plants, brick manufacturing plants, fertilizer plants, petroleum refineries and the steel industry.

21.5 Method of Monitoring

A fluoride candle is exposed to ambient air for 30-days and subsequently analyzed for fluoride content.

21.6 Location and Frequency of Monitoring

Fluoridation rate was measured at 87 locations in 1990. The monitoring locations are indicated in the Appendix (Table A-5).

21.7 Monitoring Results

The monthly values, the maximum, the standard deviation and the arithmetic and geometric means are given in the Appendix (Table A-46).

The highest annual arithmetic mean (650 µg/100 cm^2/30 days) was recorded at Hamilton (29127) with the highest monthly value (1107 µg/100 cm^2/30 days) also measured here. This station is immediately adjacent to a brick manufacturer.

During the growing season, 31 stations recorded exceedances of the monthly 30-day criterion.

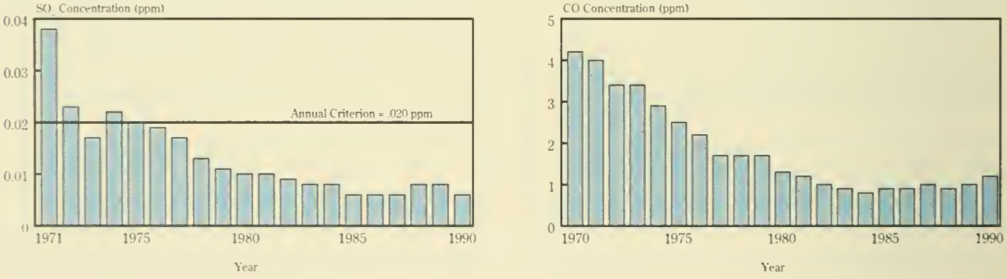
SECTION F - PROVINCIAL TRENDS IN AIR QUALITY AND EMISSIONS

The ambient air quality trends presented in this section are based on direct measurements. These trends are supplemented with trends for annual province-wide emissions from the Ontario Emissions Inventory System (OEIS). Emissions are based on the amount and kinds of pollution being emitted by automobiles, factories, and other sources, and are derived from the best available engineering calculations for a given time period. For SO_2 emissions, estimates are obtained mainly from computer calculation employing standard emission factors.

For CO, VOC and NO_x emissions, estimates for the dominant sector, i.e., gasoline and diesel-powered motor vehicles, were based upon vehicle mile tabulations and emission factors from the Mobile 4.0 model. It should be noted, however that the methods currently in use worldwide to obtain emission information from the sources may have some uncertainty. Given this uncertainty in emission estimates, the trend information is more reliable for SO_2 than for the other pollutants.

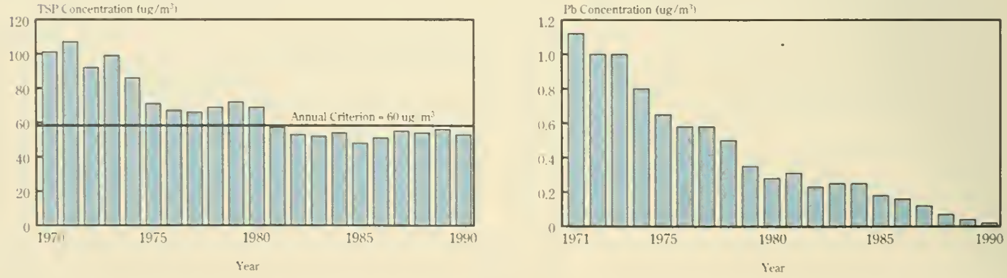
Because of changes that have occurred in ambient monitoring measurement methodology and the change over time in the geographical distribution of monitors, it is difficult to provide ambient trends going back to 1970 for all pollutants. The pollutants which can be displayed are SO_2, CO, TSP and Pb. Figure 3 shows the long term trend in the composite average of annual means for SO_2, TSP, Pb (for Windsor, London, Hamilton, Toronto and Sudbury) and CO (for Windsor, Hamilton and Toronto), at monitoring sites which have operated continuously during the past twenty years. Over this 20-year period, lead clearly shows the most impressive decrease of 98 percent. Significant improvements are

Figure 3



Long Term Trend SO_2 in Ontario

Long Term Trend CO in Ontario



Long Term Trend TSP in Ontario

Long Term Trend Pb in TSP in Ontario

also seen for SO_2 (-84 percent), CO (-76 percent) and TSP (-48 percent). For comparison purposes, the long term trend in SO_2 emissions is presented and discussed in Section 22.1.

22.1 10-Year Trend in Sulphur Dioxide (SO_2)

The 10-year trend in mean ambient SO_2, 1981 to 1990, is presented in Figure 4 and Table A-8 for twenty-five sites which possess a continuous ten-year record. Annual mean ambient SO_2 levels have improved by about 33 percent over the ten year period (84 percent over the 20 year period, see Figure 3). The majority of monitors in Ontario's urban centres meet the provincial 1-hour objective (0.25 ppm). Of the seventeen stations which exceeded the provincial 1-hour AQC in 1990, 13 were located in the Sudbury basin area. Most of the SO_2 emissions are due to large point sources in Ontario. The Inco and Falconbridge smelting operations in the Sudbury area are responsible for the large number of 1-hour exceedances there.

Smelters are a major contributor (approximately 50%) to provincial emissions of sulphur dioxide. From 1970 to 1980 there was a substantial decrease in sulphur dioxide emissions from smelters (Figure 5). There was also a significant reduction in emissions from other industrial processes due to a reduction in coal usage and lower average sulphur content in coal. The lower emissions in 1978, 1979, 1982 and 1983 were related to production shutdowns/decreases at major smelters.

From 1981 to 1990, SO_2 emissions decreased by approximately 30 percent. This decrease is largely attributed to a reduction in the average sulphur content of fuels and tighter industrial emission controls. The reduction in electrical utility emissions from 1989 to 1990 reflects an initial stage in Ontario Hydro's commitment to reduce their SO_2 emissions to a cap of 175 kilo- tonnes by 1994 under the Countdown Acid Rain program.

22.2 10-Year Trend in Carbon Monoxide (CO)

The trend in mean annual CO at locations which possess a ten-year record is shown in Table A-14 and is summarized for the province in Figure 6. From 1981 to 1983 mean ambient CO levels improved by about 33 percent; however, for the past seven years, average CO levels have remained constant at approximately 0.8 ppm with a peak 0.9 ppm in 1989.

Provincial carbon monoxide emission estimates for the same 10-year period, 1981 to 1990, show small changes (see Figure 7). The major contributor to these emissions is the transportation sector (approximately 70 percent). Improvements in emissions through the decade due to controls on vehicles were offset by increases in vehicle kilometers travelled (See Figure 8).

Figure 4
10-Year Trend for SO_2 Across Ontario

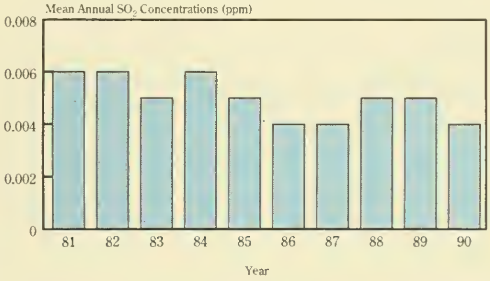
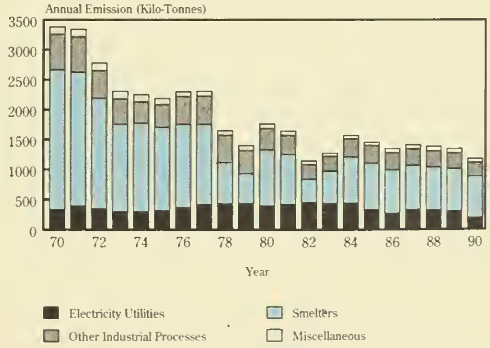


Figure 5
Ontario Sulphur Dioxide Emission Trend (1970 to 1990)



22.3 10-Year Trend in Nitrogen Dioxide (NO_2) and Nitric Oxide (NO)

The 10-year trend in the annual average of NO_2 at selected Ontario cities is summarized in Table A-19 and graphically presented in Figure 9. Nitrogen dioxide levels have remained relatively constant over the ten-year period with the exception of 1989 to 1990 which shows a 10 percent drop. Nitric oxide levels over the same 10-year period show a little more year to year variation, however, a similar 10 percent drop is evident from 1989 to 1990 (See Figure 10).

From 1981 to 1990 the estimated emission levels for nitrogen oxides showed little variation (See Figure 11). There does, however, appear to be a slight downward trend in NO_x emissions from the transportation sector.

Figure 6
10-Year Trend for CO Across Ontario

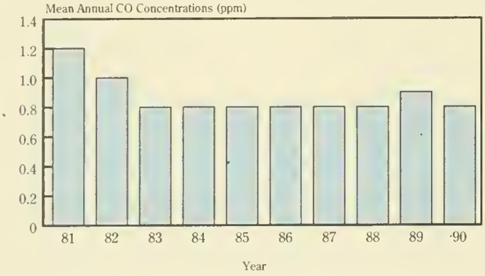


Figure 9
10-Year Trend for NO_2 Across Ontario

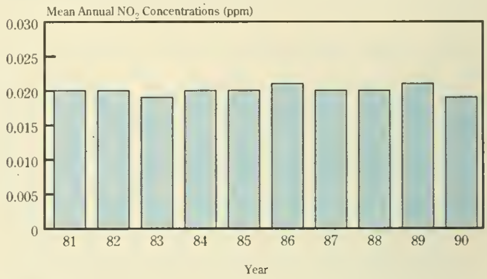


Figure 7
Ontario Carbon Monoxide Emission Trend (1981 to 1990)

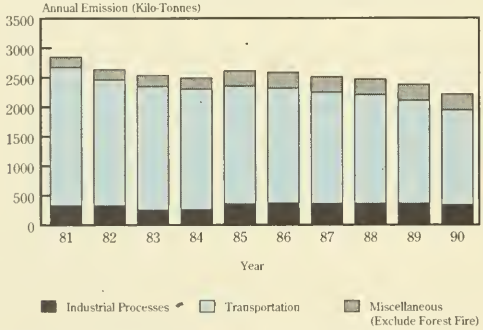


Figure 10
10-Year Trend for NO Across Ontario

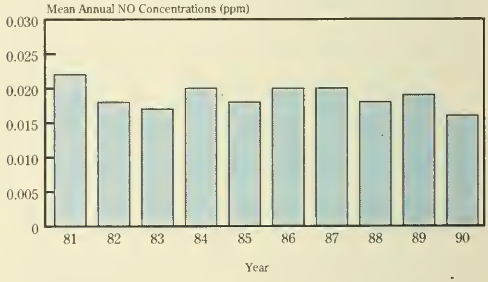


Figure 8
Ontario Vehicle-Kilometers Travelled (1981 to 1990)

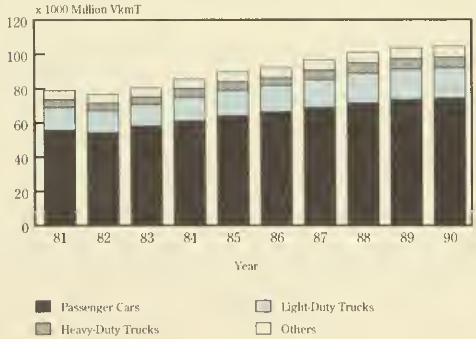


Figure 11
Ontario Nitrogen Oxides Emission Trend (1981 to 1990)

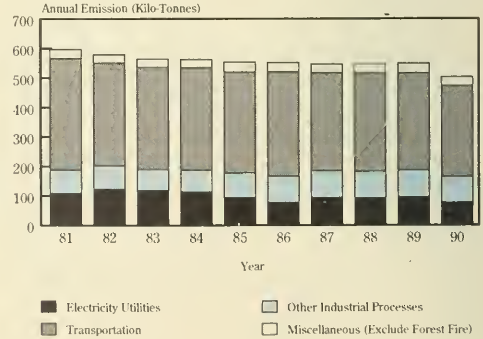


Figure 12
10-Year Trend for Ozone Across Ontario

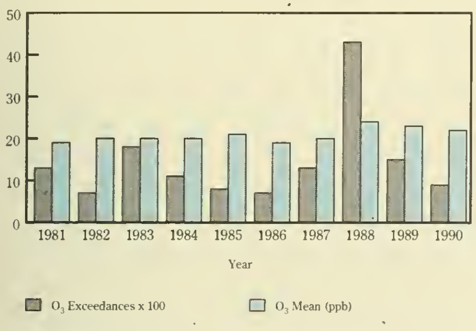
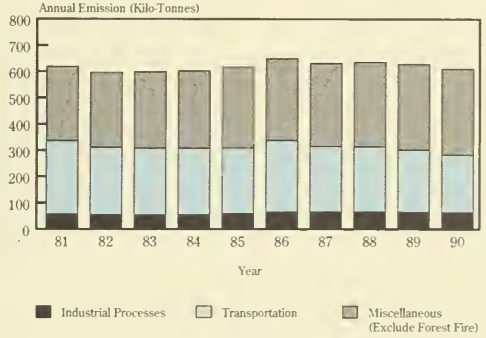


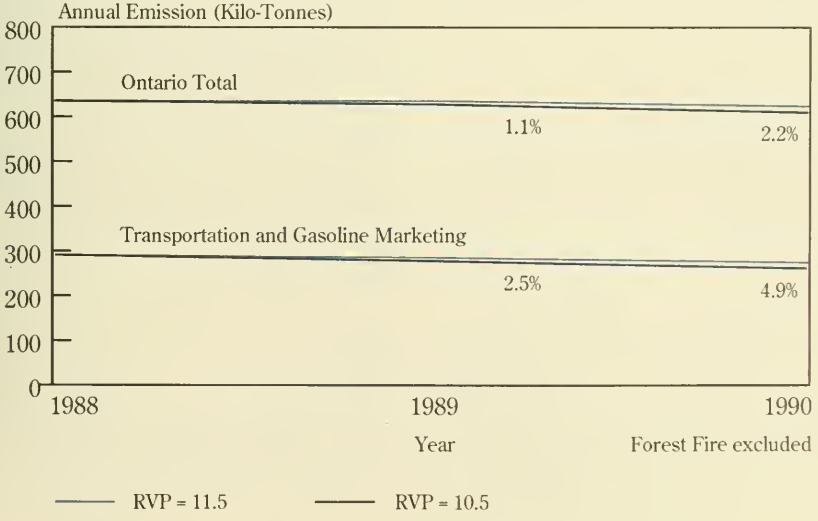
Figure 13
Ontario VOC Emission Trend (1981-1990)



22.4 10-Year Trends in Ozone (O_3)

The ten-year trend in mean annual ozone levels and number of exceedances of the provincial 1-hour objective (80 ppb) for 23 ozone sites (1981-1990) is displayed in Figure 12 and Table A-24. Except for 1988, the provincial mean annual ozone level has remained relatively constant. There is some variability at specific sites but no apparent trend. The figure also shows that Ontario's air quality criterion for ozone is frequently exceeded; however, there is no particular trend in these exceedances except that in 1988 summer ozone levels were unusually high, with the highest number of exceedances of the Ontario criterion. The hot, dry, and often stagnant conditions throughout the summer of 1988 were more conducive to ozone formation than in other years.

Figure 14
Reduction in Ontario VOC Emission Due to Lower Gasoline RVP in Summer



1989: Use of RVP 10.5 gasoline in 2 summer months
1990: Use of RVP 10.5 gasoline in 3 summer months

Meteorological conditions in the summer of 1990 were less conducive to ozone formation than 1988 and 1989. (See also Section 25.0).

Figure 13 shows the 10-year provincial trend for emissions of volatile organic compounds (VOC). These compounds along with nitrogen oxides are involved in the photochemical formation of ozone. It should be noted that the VOC emissions in Figure 13 do not include emissions from forest fires or natural emissions, the latter which represent a large contribution for Ontario. For example, the natural VOC emissions in Ontario were estimated to be about a factor of 3 times higher than the anthropogenic VOC emissions in 1988. The VOC emission levels show little variation from 1981 to 1990.

The Ontario Ministry of the Environment instituted a program to reduce the Reid Vapour Pressure (RVP) from 11.5 psi to 10.5 psi during the summer months beginning in 1989. Similar or larger reductions in the RVP have been introduced for states south of Ontario since 1989. As a result of this reduction in RVP, the reduction in reactive hydrocarbon emissions from the transportation sector including gasoline handling has been estimated to be less than 4 percent of the total man made emissions in Ontario (see Figure 14). The net reduction in reactive hydrocarbon emissions is relatively small compared to the total man made plus natural emissions. Its impact on ozone production is, therefore, difficult to see in the trend of O_3 for 1989 to 1990. Although O_3 levels have dropped during the two year period they are higher than or comparable to the O_3 levels during 1981 to 1987 when the RVP was 11.5 psi. The trend in ozone during 1989 to 1990 can be attributed mostly to meteorological variability as was the case in 1988.

22.5 10-Year Trends in Suspended Particles (SP)

The trend in mean annual SP at selected Ontario cities is shown in Table A-10 and summarized for the province in Figure 15. Fine particulate, as determined by SP, has remained relatively constant over the ten year period 1981-1990. However, as previously stated, the 24-hour criterion for suspended particles was the second most frequently exceeded AQC during 1990.

22.6 10-Year Trend in Total Reduced Sulphur (TRS)

Table A-12 shows the ten-year trend in mean annual TRS for selected Ontario cities while Figure 16 shows the provincial trend with a minimum composite mean in 1985 and a general increasing trend over the last five years. The minimum in 1985 is due to production shutdowns/decreases at the kraft pulp mills in Fort Frances and Cornwall.

22.7 10-Year Trends in Particulate Matter (TSP)

The trend in mean annual TSP at 31 sites which possess a ten-year record is shown in Table A-26 and summarized for the province in Figure 17. Particulate levels across Ontario have improved by 15 percent over the 10-year period 1981 to 1990. However, as stated earlier, thirty-six percent of the stations measuring for TSP exceeded the 24-hour criterion and fourteen percent exceeded the annual criterion. Even though particulate levels province-wide are decreasing, levels at some sites in major urban centres such as Hamilton, Windsor and Toronto continue to exceed the Ontario criteria (See Section 23.0).

Figure 18 shows the 1981 to 1990 levels of Ontario particulate emissions from industrial processes, transportation sources and other sources such as fuel combustion. Forest fires are not included in this trend graph. Ontario particulate emissions from forest fires can be a significant fraction of the total emissions (for example, in 1980 particulate emissions from forest fires was estimated to be about a factor of 4 times

Figure 15
10-Year Trend for SP Across Ontario

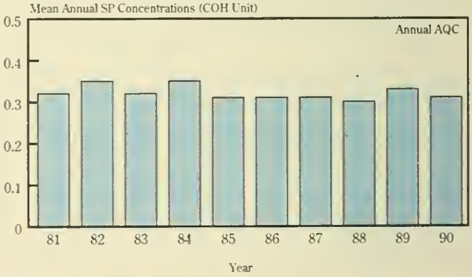
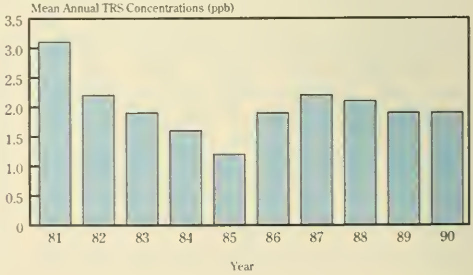


Figure 16
10-Year Trend for TRS Across Ontario



higher than the anthropogenic total) and they vary dramatically from year to year. Anthropogenic particulate emissions show no significant changes from 1981 to 1990. It should also be noted that fugitive emissions are not included in Figure 18. Since fugitive emissions from sources such as entrained road dust, construction activity and wind blown dust can be the dominant source of ambient TSP levels, the trend in measured TSP values would not necessarily follow the emissions trend.

Figure 17
10-Year Trend for TSP Across Ontario

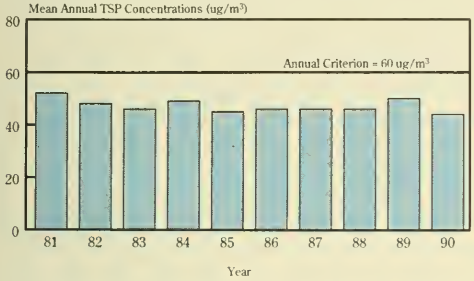
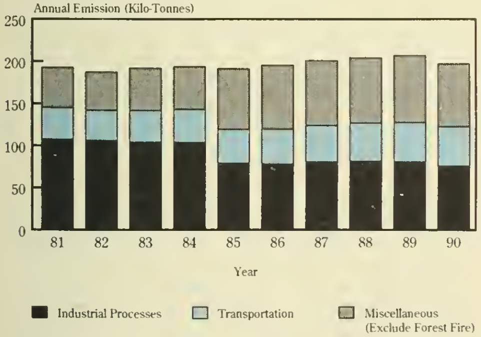


Figure 18
Ontario Particulate Emission Trend (1981-1990)



22.8 10-Year Trend in Lead in TSP (Pb)

Lead levels in air have improved very significantly over the past 10-year period as shown in Figure 19. The ambient lead levels presented here primarily represent general urban conditions predominantly reflecting automotive sources. The trend at selected Ontario cities is shown in Table A-29. Lead levels have declined by 95 percent during the period 1981 to 1990. This decline is due to the increased use of unleaded gasoline in catalyst-equipped cars and the reduced Pb content in leaded gasoline. Lead emissions from gasoline use will be effectively eliminated beyond 1990 because the addition to gasoline was prohibited after December 1, 1990.

As mentioned earlier, the highest concentrations of lead are measured in the vicinity of secondary lead processing plants. These plants tend to be located in urban areas and therefore remain an environmental concern. Emissions from these plants are being closely monitored.

22.9 10-Year Trend in Manganese in TSP (Mn)

Table A-33 provides the ten-year trend for average manganese at the stations where a ten-year record exists. Figure 20 summarizes the data for the province. Manganese levels have increased by 28 percent over the period 1981 to 1990. In order to raise the fuel octane level in the absence of lead, a manganese compound was added to gasoline. This manganese compound is a contributing factor to the increase in Mn levels in Ontario.

22.10 10-Year Trend in Copper in TSP (Cu)

The trend in mean ambient copper levels is shown in Table A-39 and summarized for Ontario in Figure 21. Copper levels have decreased by 70 percent over the 10-year period (1981-1990). However, it should be noted that in the earlier sampling period the copper data may have been affected by the contamination of the sample by the hivol motor. No attempt has been made to correct the data.

22.11 10-Year Trend in Iron in TSP (Fe)

The trend in mean annual iron is shown in Table A-31 and is summarized for the province in Figure 22. Iron levels were constant during the 1982 to 1986 period and have increased by about 10 percent over the last 4 years.

22.12 10-Year Trend in Nitrate in TSP (NO_3^-)

The trend in mean annual nitrate at locations which possess a ten-year record is shown in Table A-42 and summarized for the province in Figure 23. The nitrate variability from year to year is largely related to meteorological variability since nitrate is primarily the result of medium and long range transport of air pollution.

22.13 10-Year Trend in Sulphate in TSP (SO_4^{2-})

The trend in mean annual sulphate levels is shown in Table A-44 and summarized for the province in Figure 24. As in the case of nitrate, the sulphate variability may also be explained by meteorological variability.

Figure 19
10-Year Trend for Pb in TSP Across Ontario

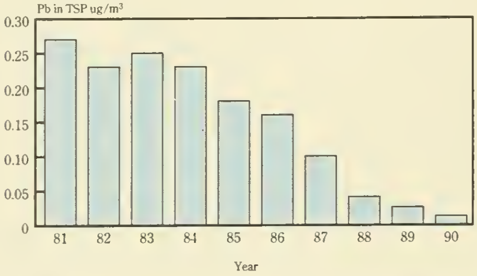


Figure 20
10-Year Trend for Mn in TSP Across Ontario

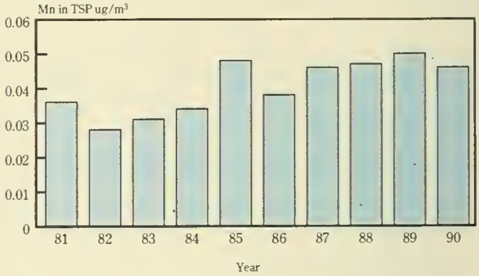


Figure 21
10-Year Trend for CU in TSP Across Ontario

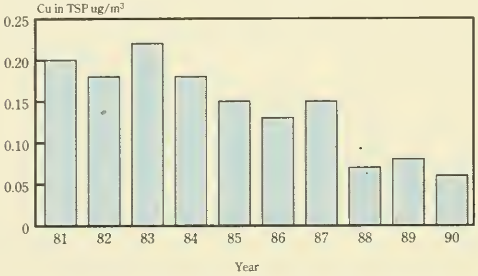


Figure 22
10-Year Trend for Fe in TSP Across Ontario

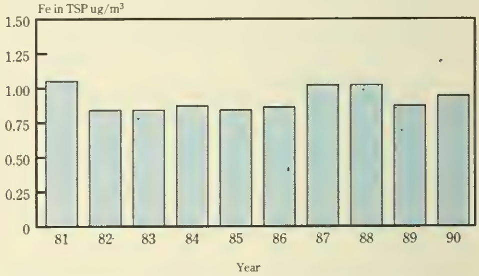


Figure 23
10-Year Trend for NO_3^- in TSP Across Ontario

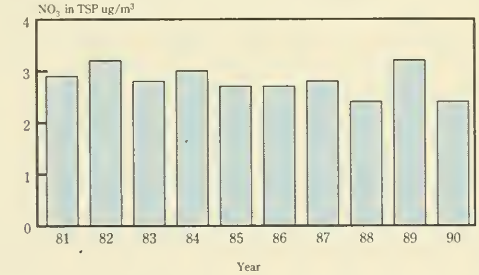
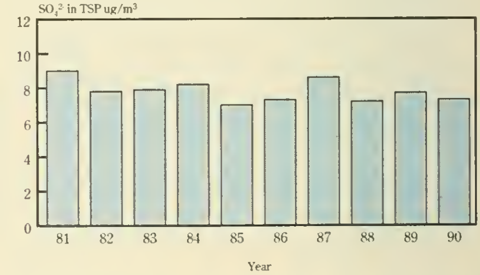


Figure 24
10-Year Trend for SO_4 in TSP Across Ontario



- trend plots are based on mean annual concentrations in μg/m³

23.0 Ambient Air Quality Comparison at Selected North American Cities

This section focuses on a brief comparison of ambient air quality levels in selected North American cities. The three largest Canadian cities (Toronto, Montreal and Vancouver) and three major U.S. cities (Chicago, Boston and Atlanta) are compared using the five most common and routinely monitored urban air pollutants. These include sulphur dioxide (SO_2), total suspended particulate matter (TSP), nitrogen dioxide (NO_2), carbon monoxide (CO) and ozone (O_3).

Ambient air quality levels for these 5 pollutants in each of these cities for the most recent comparable year (1989) are displayed graphically in Figures 25 (a-e). In Figures 25 (a-c) a box plot bar graph is used to display the minimum and maximum annual mean and the "ensemble average." The ambient air quality criteria for Ontario (AQC), the Canadian National ambient air quality objectives (NAAQC) and the US EPA air quality standards are represented on these Figures where possible.

Sulphur dioxide (SO_2) levels measured in Metro Toronto are slightly lower in comparison to the other cities (with the exception of Vancouver). All of the SO_2 monitoring sites in each of these cities are well within the annual SO_2 criteria of 0.02 ppm (Ontario) and 0.03 ppm (US EPA).

Total suspended particulates (TSP) continue to present some problems in many areas of Metro Toronto, where the annual TSP criterion of 60 $\mu g/m^3$ was exceeded at 66% of the monitoring sites in 1989.

Nitrogen dioxide (NO_2) levels are relatively low in each of these cities and are well below the US EPA and NAAQC annual criterion of 0.05 ppm. The highest 1989 annual mean levels (composite average) are recorded at sites in Metro Toronto and Boston.

Carbon monoxide (CO) levels are generally higher in the three Canadian cities. There were no exceedances of the Ontario AQC for CO. The highest 8-hour maximum of 13 ppm (which is the more restrictive limit) was measured at the Mission site (31049) in Toronto, located in a street canyon with poor dispersion conditions and a high volume of slow-moving traffic. Other areas in Metro Toronto generally experience acceptable CO concentrations.

Ozone (O_3) is the pollutant which most frequently exceeds the Ontario AQC in Metro Toronto; and on some occasions O_3 levels in in Toronto exceeded the less stringent US EPA standard of 120 ppb.

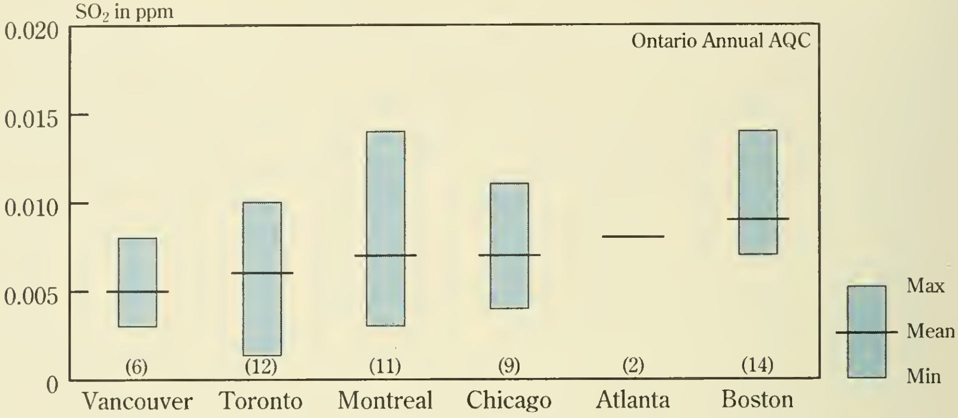
In summary, in order to collectively compare the air quality levels in the six cities, each city was ranked according to the five individual criterion pollutants using all the data measured in the monitoring networks in each metropolitan area. The individual rankings were summed to determine an overall score. The results were Toronto (24.5), Chicago (19.5), Boston (18.5), Atlanta (17.5), Montreal (17.0) and Vancouver (8.0), see Table 9. Based on the results, ambient air quality in Metro Toronto was worse than that in Chicago, Boston, Atlanta, Montreal and Vancouver during 1989.

TABLE 9: RANKING OF METROPOLITAN AREAS ACCORDING TO CRITERION POLLUTANT LEVELS

Metropolitan Area	Rankings					Total Score
	SO_2	TSP	NO_2	CO	O_3	
Atlanta	5	2	2 tie	3	5	17.5
Boston	6	3	5 tie	1	3	18.5
Chicago	4 tie	6	4	2	4	19.5
Montreal	3 tie	4	3 tie	5	2	17.0
Toronto	2	5	6 tie	6	6	24.5
Vancouver	1	1	1	4	1	8.0

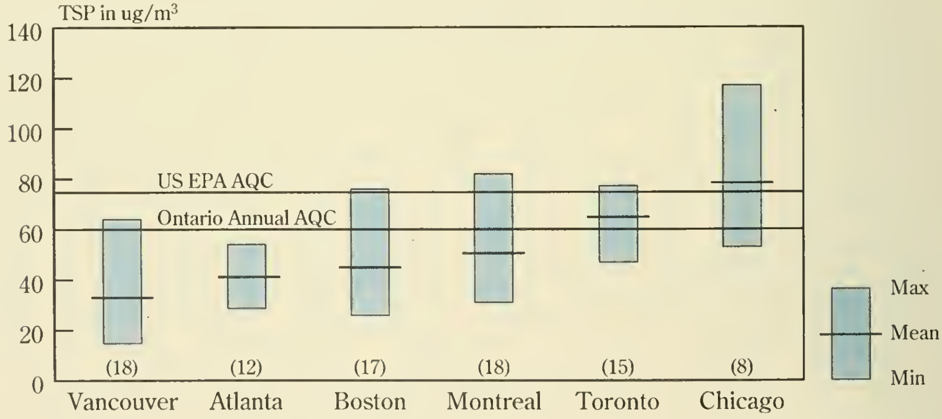
- individual rankings are summed for each Metropolitan area to determine an overall score.
- in the case of a tie the rankings are averaged.

Figure 25a
Comparison of Annual SO_2 Levels at Selected North American Cities (1989)



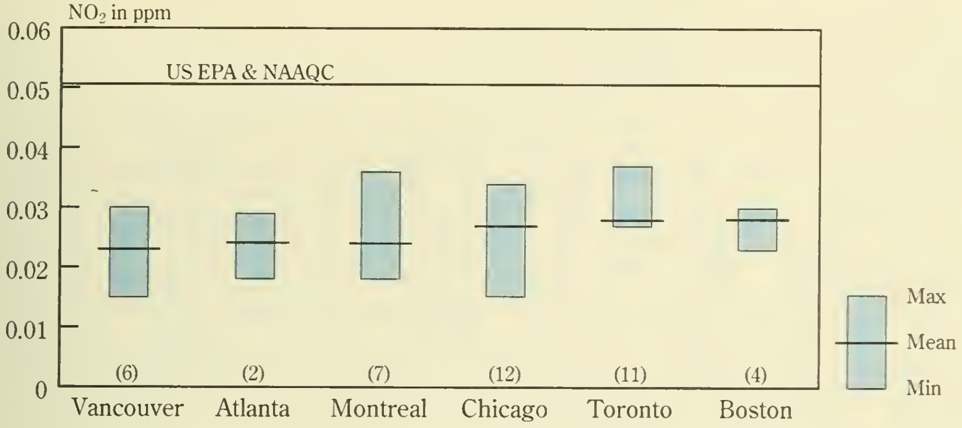
( ) - Number of Stations

Figure 25b
Comparison of Annual TSP Levels at Selected North American Cities (1989)



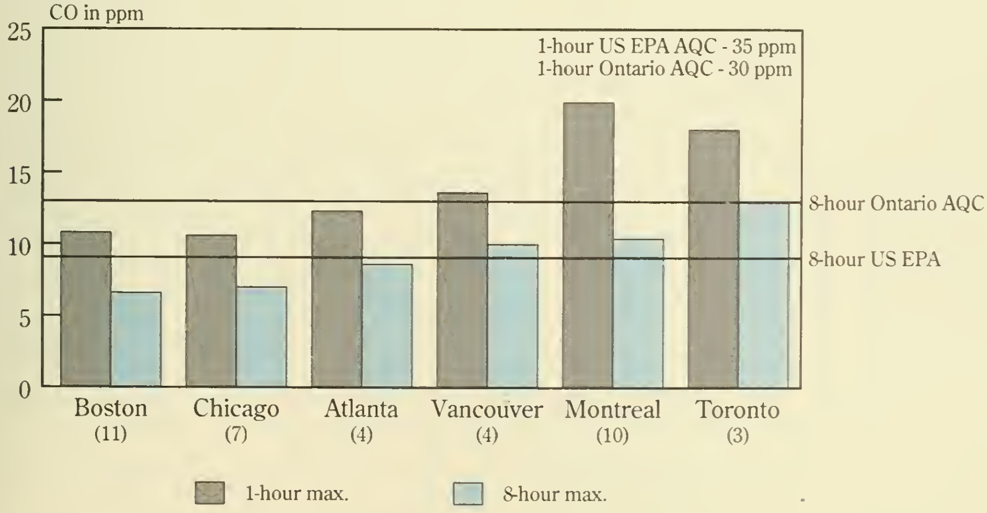
( ) - Number of Stations

Figure 25c
Comparison of Annual NO_2 Levels at Selected North American Cities (1989)



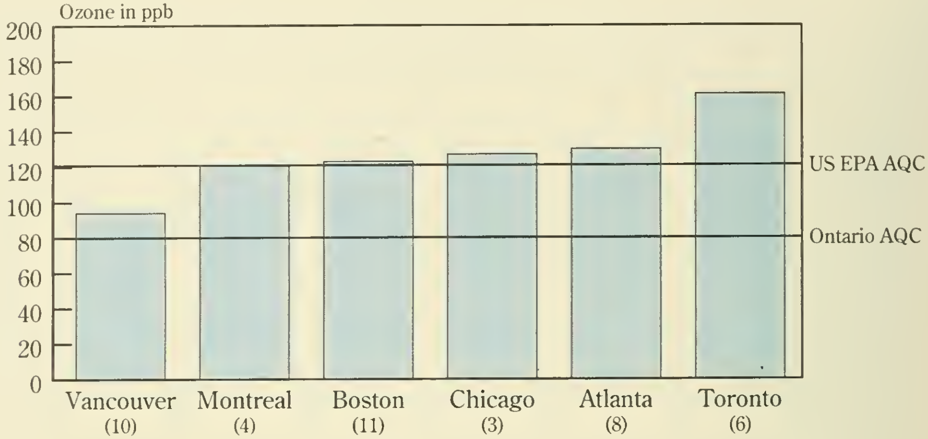
( ) - Number of Stations

Figure 25d
Comparison of CO Levels at Selected North American Cities (1989)



( ) - Number of Stations

Figure 25e
Comparison of 1-Hour Maximum O_3 Levels at Selected North American Cities (1989)



( ) - Number of Stations

SECTION G - METEOROLOGY AND AIR QUALITY

Weather conditions play a major role in the levels of air pollution. Weather factors which affect air pollutant concentrations are:

- wind, which transports and disperses pollutants emitted from sources,
- temperature, which affects the amount of fuel used and the dispersion and chemical reactions of pollutants in the atmosphere,
- slow moving high pressure systems, which allow pollutant concentrations to build up in the atmosphere,
- rainfall, which may remove (washout) pollutants from the atmosphere, and
- sunshine, which causes photochemical reactions of air pollutants which form smog.

24.0 Summary of Meteorological Conditions (1990)

In Figures A-1 to A-8, weather statistics are presented for a number of sites across the province. The annual mean temperature for 1990 at the majority of locations across Ontario was above normal. However, during the summer months, temperatures in southwestern Ontario were below normal. June was wet and cloudy. Since the inception of the AQI system in May 1988, and in fact since 1986, this was the first time that temperatures in June in many areas of Ontario failed to reach 30° C at least once. July (1990) can be ranked as the coolest July since 1985, with most sites across Ontario recording mean air temperatures near normal.

The number of days recording temperatures 25° C and above was markedly less than the number recorded during 1988; the number of hot days with temperature above 30° C was also markedly less than the number recorded during the hot July of 1988. In Toronto, there were only 3 days with temperatures above 30° C compared to 11 in 1988. Windsor recorded only 5 such days in 1990 compared to 19 in 1988. Rainfall across the province was near normal.

During August mean temperatures ranged from near normal in southwestern Ontario to 1° C above normal in northern and eastern Ontario. In southwestern Ontario, London received approximately 55 percent more than its normal rainfall and 20 percent less than the normal hours of bright sunshine. London also did not record any days with temperatures greater than 30° C.

Thunder Bay and Sudbury received less rainfall in August (1990) than in the two previous years. However, Sudbury did not record any days with temperatures greater than 30° C for this month.

Summer on the average was cooler than the previous two years, however, temperatures were slightly warmer than the long term mean at the majority of sites across the province.

Annual wind roses are presented in Figure 26 for selected meteorological sites across Ontario. The entire meteorological network is outlined in Table A-6 and Maps 6 and 7.

25.0 Discussion of Ozone and Suspended Particle Episodes

Ozone exceedances are confined primarily to the summer months and are strongly influenced by meteorological conditions, particularly large slow moving high pressure systems. Elevated ozone levels which tend to cover large regions of eastern North America (including southern Ontario) are found typically on the rear sides of high pressure systems or in the warm sectors of low pressure systems. To analyze ozone episodes and their relationship to meteorological conditions, "episode-days" are defined as days on which widespread (hundred of kilometres) elevated ozone levels (greater than 80 ppb maximum hourly concentration) occurred on the same day at more than eight monitoring sites and "episodes" are defined as distinct events associated with episode days. There were 13 episode days during 1990 compared to 36 and 18 episode days in 1988 and 1989 respectively. Exceedances during 1990 were substantially less than the number recorded during the hot dry summer of 1988 and were only 66 percent of the number recorded during 1989. Due to the reduced number of hot days (days with temperature greater than 30° C) and fewer hours of bright sunshine recorded during the summer of 1990 in combination with above normal amounts of rainfall as discussed in the previous section, ozone exceedances were markedly reduced.

The first ozone episode of 1990 occurred on Saturday, April 28, when 21 AQI sites across Ontario recorded elevated ozone levels. The occurrence of elevated levels of ozone was due to a persistent "back of the high/warm sector" situation. On Monday, April 23 a ridge of high pressure moved eastward across southern Ontario and stalled over the eastern sea-board. A light south to southwesterly flow was then established over southern Ontario and by the evening of April 24, southern and northeastern Ontario were under the influence of a mainly cloud free, hot and stable air mass. Daily maximum temperatures during the period April 24 - 29 ranged from 27° to 31° C, and ozone exceedances occurred at various sites on each day. On April 30, clouds associated with an eastward moving cold front inhibited further ozone formation. The cold front swept across southern Ontario during the night of May 1, advecting a much cleaner air mass over the area.

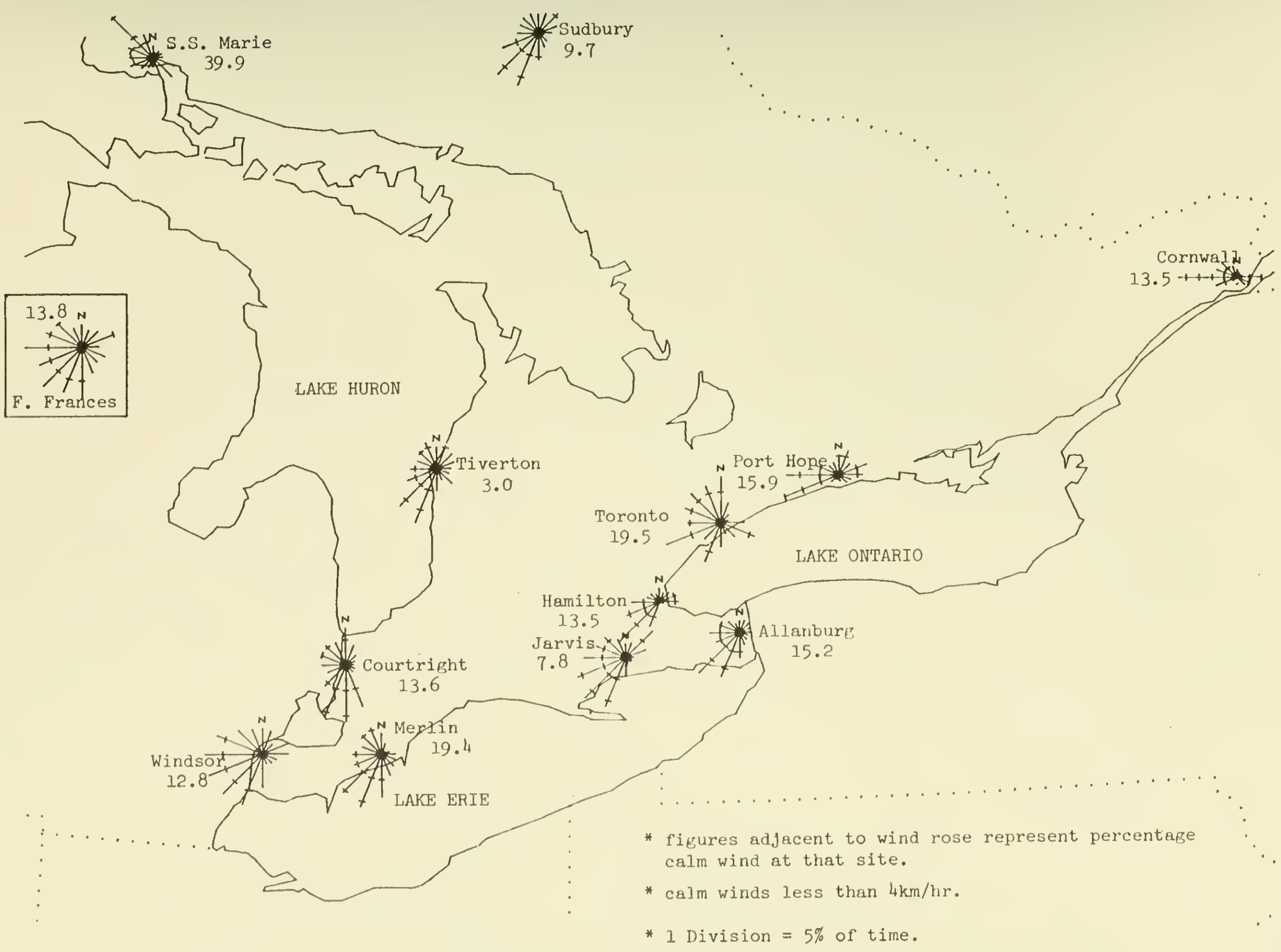
In 1990, there were 9 episodes of 1 days' duration and 2 episodes of 2 days' duration. The last ozone episode occurred on August 17, 1990.

Elevated levels of suspended particles generally occur on days with light wind conditions and surface based temperature inversions which can reduce the upward mixing of pollutants. This trapping of pollutants close to the surface results in a build-up of suspended particle concentrations during the morning rush hour.

During 1990, there were 1089 hourly exceedances due to suspended particles. These exceedances were less than 80 percent of the exceedances due to supended particles recorded in 1989, the first complete year of the operation of the AQI system. When light wind speed and inversion conditions persist for a day or more, the elevated suspended particulate values can cause the API (see Section 12.0) to reach 32. Except for Sudbury where SO_2 dominates, API exceedances are due primarily to suspended particles.

The first API episode in 1990 was due primarily to elevated levels of suspended particles and was experienced at sites in Hamilton and Metro Toronto during the period March 14 to March 16. Prolonged adverse air pollution levels were recorded in Hamilton with the simultaneous occurrence of light winds from the northeast and a capping inversion above the 60 metre level as measured at the Hamilton (29026) meteorological tower site. For the duration of the episode, Hamilton was within the warm sector of a frontal wave with light winds throughout the period. The capping inversion above 60 meters was not eroded throughout the period. On March 14 and 15, the air temperature at the synoptic scale as recorded at Hamilton airport on top of the escarpment displayed the normal diurnal trend of increasing throughout the daylight hours and reaching maximum values during the afternoon. However, at Hamilton harbour the air temperature decreased during the afternoon as northeast winds advected cooler air from the lake into the city. Since the airport recorded southwesterly winds during the afternoon, a lake breeze circulation was set up below the escarpment. On Friday, March 16, a cold front accompanied with showers moved across Ontario thus cleaning the atmosphere and bringing an end to the suspended particle episode. This suspended particle episode was the worst recorded during 1990.

Figure 26: Annual Wind Roses for Selected Meteorological Sites Across Ontario



* figures adjacent to wind rose represent percentage calm wind at that site.

* calm winds less than 4km/hr.

* 1 Division = 5% of time.